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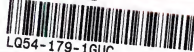
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Popular Science

1999 BEST OF WHAT'S NEW

100 OF THE YEAR'S GREATEST ACHIEVEMENTS IN SCIENCE & TECHNOLOGY

Founded in 1872 • Volume 255 • Number 6

SCIENCE & TECHNOLOGY

23 Science & Technology Newsfront Astronaut assistants; soft-ball-size robots; beating urban heat.

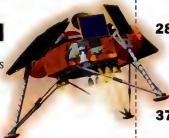
59 COVER STORY The Best of What's New Science and technology are setting the stage for changes that will transform life in the 21st century. Consider our 12th annual salute to the year's 100 top achievements a primer for the new millennium.

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AVIATION & SPACE

100 Mars Invasion Two tiny probes and a lander will descend to the Red Planet this month, seeking to solve its deepest mysteries.

116 Are the Russians Lost in Space? With Russia's participation in doubt, NASA is scrambling to revise plans for the troubled International Space Station.



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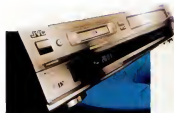
50 Home Technology Newsfront Superthin solar cells; last-minute Y2K checklist; jack-of-all-utilities.

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28 Automotive Newsfront New fuel-efficiency champ; no-draggin' sport wagon; roomier Taurus.

ELECTRONICS

37 Electronics Newsfront Sneak preview 2000: digital-analog VCR; recordable DVD player; Internet-savvy fax; voice-operated TV/VCR.



This is a very special year-end issue for POPULAR SCIENCE—the last Best of What's New Awards of the century and our 12th annual. As in previous years, the editors (below) gathered, evaluated, and debated literally thousands of the most innovative, cutting-edge discoveries, products, and technologies the world could think up. From a pet robot dog named Aibo to a next-generation oven that bakes cookies in only 2 minutes to a watch that automatically adjusts to whatever time zone you're in, these achievements—whether they be functional or merely fun—offer a glimpse at the advances we can yet expect in the 21st century.

This issue also brings to a close our special yearlong celebration of the 100 inventions that have had the greatest impact on our lives during this millennium. To give you a better idea of how prolific humans truly are, consider that the U.S. Patents and Trademarks Office received more than 250,000 applications in the past year alone. Clearly, the inventive spirit is alive and well and poised to see us into the next century and beyond. Just wait 'til you see what marvels await you in these pages next year. See you then.—Cecilia Wessner



PHOTOGRAPHY JOHN B. CARNETT

THE 1999 BEST OF WHAT'S NEW >





Bio Bonanza

THE OCTOBER issue on the bioengineering of humans was full of fascinating and uplifting articles that broadened my understanding about the human condition.

Gene Behnke
Sacramento, Calif.

Monkey Business

IN "Organ Cowboy" [Oct.], you state that primates are not being pursued as a source of organs for transplants into ailing humans for ethical reasons. As a consequence, thousands of people are dying while researchers work through the extremely difficult problems of adapting pig organs for human transplants. That strikes me as an appalling lack of ethics.

Tom Hanks
Coal Valley, Ill.

Earlier Sea Launches

YOUR article on the floating launch pad named *Odyssey* did not mention that satellites have previously been launched into equatorial orbit from the ocean ["From Sea to Space" Sept.]. The San Marco Equatorial Range project is a collaborative effort between the United States and Italy

set up in 1964 expressly for that purpose. The project consists mainly of three platforms connected by submarine cables that sit in the Indian Ocean, off the Kenya coast. One platform is for vehicle assembly, testing, and launching; the second is for communications; and the third houses radar for satellite tracking and other equipment. Two additional small platforms contain the electrical power-generation plant.

Unlike the floating *Odyssey*, the San Marco platforms stand on steel "legs" above the ocean. Since 1964, the platform has launched nine satellites (four of them NASA's) into equatorial orbits, some of them with international cooperation. The project continues to launch satellites and support tracking operations for satellites it has already launched.

Lee Foster
Former Project Manager
Scout Launch Vehicle and
San Marco Programs
Toano, Va.

Aerodynamic Automobiles

I ENJOYED your article on General Motors' newest streamlined prototype automobile ["The Slippery Car," Automotive Newsfront, Oct.], especially the timeline showing all the neat streamlined production cars. But you left out one of the largest production streamlined cars, the Czech-built Tatra. Like the new General Motors car, the Tatra had a rear engine. My 1962 T2-603 has a wind-cheating body underneath as well as above: All cables, lines, and wiring are inside the car, even the linkages for the rack and pinion steering. Wherever I park the car, it draws a crowd. For more information on Tatra automobiles and trucks, I suggest checking out www.team.net/www/ktud/Tatra.html.

Bill McCoskey
Mt. Airy, Md.

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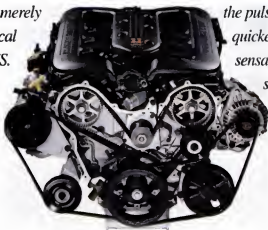
An automatic transmission that lets you decide when to shift? Gee. An available aluminum, 225 horsepower, 3.2 liter V-6, designed and proven in cyberspace? Gee. A sleek cab-forward sedan that feels roomier than some city apartments? Gee. These are merely a few examples of the technological artistry behind Dodge Intrepid ES.

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Copy-Proof CDs? Yikes!

IN "Copy-Proof CDs" [Electronics Newsfront, Oct.], you say that United Kingdom-based C-Dilla is working on a technology to render newly manufactured music CDs unplayable on a standard CD-ROM drive. I can only hope this technology never comes into use. I play music CDs on my computer exclusively because I don't own a stand-alone CD player. If the music industry were to adopt the technology, I'd be forced to drop a couple of hundred dollars on a piece of hardware that will likely become redundant in a few years. Ridiculous!

Trevor Kidd

*Gloucester, Ontario
Canada*

Parachutes and Airplanes

"IF Airplanes Had Parachutes" [Reality Tech, Oct.] distorts the picture of general aviation safety. While the article claims "three to four planes a day are lost to spatial disorientation," statistics from the Aircraft Owners and Pilots Association Air Safety Foundation demonstrate that spatial disorientation was a cause or factor in only 35 accidents in 1996 (the last year for which full data is available). That number has declined steadily since the 1980s due in part to today's private pilot training, which includes at least 3 hours of instrument instruction to teach pilots how to cope with spatial disorientation.

Both automobiles and general aviation are riskier than the major U.S. air carriers. But nothing can compare with the airlines' 1998 record of no passenger deaths. The airlines operate in a tightly controlled environment, with repetitive operations to a limited number of airports (about 600) using highly trained crews flying the best equipment.

General aviation serves some 13,000 facilities of all kinds. Included in the general aviation safety statistics are inherently riskier operations such as powerline and pipeline patrol, aerial agricultural applications, Alaska bush flying, forest fire fighting from the air, and law enforcement flying.

Yet, there were just 361 fatal general aviation accidents in 1998, during 35 million flights and 27 million hours in the air. And the record continues to improve. The number of fatal accidents today is half of what it was in the 1970s.

Warren Morningstar

*Aircraft Owners and Pilots Association
Frederick, Md.*

I PILOT A Boeing 777 for American Airlines, and I believe that your suggestion that a huge parachute would have saved John F. Kennedy Jr. is absurd. First, he would have had to know that he was in a life-threatening situation to deploy the chute. Then he would have had to be within the capabilities of the rescue chute. Deploying this device

hollywood

is almost a guarantee that you have lost your aircraft (either a hard earthbound landing or in the water, to sink eventually). That in itself will make it near impossible for most pilots to use, admitting in a time of stress that they are so screwed up that the plane is a total loss before you hit the ground. That leads to one more consideration: Kennedy's grasp of the situation. He may not have even been aware that he was out of control until the aircraft contacted the water.

Jim K. Walton
Highland Village, Tex.

Corrections: Gene therapy clinical trials to treat muscular dystrophy are being led by researchers at the University of Pennsylvania in Philadelphia ["Mending Broken Genes," Reality Tech, Oct.].

The ball in a tube in John F. Kennedy Jr.'s Piper Saratoga aircraft was a slip indicator ["If Airplanes Had Parachutes," Reality Tech, Oct.].

INVENTIONS

The Readers' Choices

THANKS TO ALL of you who sent in ideas for this year's series on the 100 greatest inventions of the millennium. We received around 1,000 nominations.

Your mail ranged from serious discussions of Tesla's work on alternating current (he has a lot of fans among you) to nominations of sliced bread. Our favorite was from the reader who nominated POPULAR SCIENCE. For more about the series, see www.popsi.com. Here then are your top 10 picks:

10. Television
9. Internet/Web
8. Microchip
7. Telephone/cellphone
6. Automobile
5. Printing press
4. Light bulb
3. Toilet/indoor plumbing
2. Personal computer
1. Electricity



silicon valley



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REALITY TECH

BY FRED ABATEMARCO

News at the Digital Divide

THIS YEAR'S good-news/bad-news report on technology usage in the United States from the Commerce Department, "Falling Through the Net III: Defining the Digital Divide," contains hardly any surprises. And that really got my attention. The upside is that computer ownership and Internet connectivity are

booming. The number of homes with a computer has nearly doubled in the past four years. Today, the computer has taken up appliance status in more than 42 percent of households across the United States.

And these computers are increasingly being wired to the Internet. Online access was up more than 50 percent in just the past year (from 1997 to 1998). Now, more than one-quarter of all U.S. households can surf in cyberspace.

Mostly, this explosive growth has occurred democratically. The online penetration and computer ownership increases extend across all the demographic levels—by race, geography, income, and education.

We view these trends as favorable without the slightest question because we clearly see computer technology as empowering. In fact, personal growth and a prosperous U.S. economy are considered to be the long-range rewards of individual and collective technological prowess. I myself am hoping that such assumptions are true and that world peace, love, understanding, and perhaps a cure for the common cold or a world championship for the Mets will somehow be future byproducts.

Pretty rosy picture, right? Now for the not-so-good news. The government's analysis spells out a so-

called digital divide. That is, the digital explosion is not booming at the same pace for everyone. Yes, it is true that we are all plugged in to a much greater degree than any of us have been in the past. But in a sort of Orwellian twist, some of us are more plugged in than others and are getting plugged in far more rapidly. And this gap is widening even as the pace of the information age accelerates through society.

Computer ownership and Internet access are highly stratified along lines of wealth, race, education, and geography. As you might suspect, the data indicates that computer ownership and online access is growing more rapidly among the most prosperous and well educated: essentially, wealthy white people with high-school and college diplomas and who are part of stable, two-parent households.

The highest income bracket households, those earning more than \$75,000 annually, are 20 times as likely to have access to the Internet as households at the lowest income levels, under \$10,000 annually. The computer penetration rate at the high-income level is an astounding 76.5 percent, compared with 8 percent at the bottom end of the scale.

Technology access differs widely by educational level. College graduates are 16 times as likely to be Inter-

net surfers at home as are those with only elementary-school education. If you look at the differences between these groups in rural areas, the gap widens to a twenty-six-fold advantage for the college-educated.

From the time of the last study, the information access gap grew by 29 percent between the highest and lowest income groups, and by 25 percent between the highest and lowest education levels.

In what the Commerce Department labels a racial ravine, whites have significantly greater Internet access than blacks and Hispanics. Nearly 27 percent of whites have access to the Internet from home. That compares with 19 percent of blacks and about 17 percent of Hispanics having access from any location at all, whether at home, work, school, or a community center. Even though computer penetration for blacks and Hispanics more than doubled between 1994 and 1998, the gap in household access to the Internet between blacks and whites and Hispanics and whites grew by more than 50 percent.

"The disparities between races are significant and they are grow-



JOHN B. CARNETT

ing," the government's report warns.

This bad news is old news. Advantage to the advantaged is not a concept spawned by the technology revolution. And because it's all too easy to greet this development with a jaded yawn, alarm bells should be-

gin sounding. Especially since the trends cited in "Falling Through the Net III" echo those of previous studies from the Commerce Department and from other sources. Versions I and II of the report, published in 1998 and 1995, respectively, also

targeted the deepening gap.

In the long run, participation in the information age may not be a zero sum game, where if some groups win, others must lose. Eventually, as the technology matures we are likely to see penetration levels approach parity across all groups. This was true for telephone access and television ownership. But eventually it can be cold comfort in an era when tomorrow is radically different from today and unrecognizable compared with yesterday.

And this time, the stakes are higher. Being familiar with technology is not an option but a necessity for present and future generations. Never has technology or our relationship to it had such an onus.

We have a public policy challenge right now to do some steering to reverse the digital divide. Happily, not everything must be regulated or legislated. Free market dynamics obviously underpin most of the technological surge of the past 20 years. Knowing that computer and telecommunications costs continue to plummet is a positive sign that we'll someday approach full buy-in to the computer age.

Perhaps the stickiest point right now is the controversy over the education rate, a program in which telephone fees are used to finance grants that discount the cost of school and library connections to the Internet. Telecommunications companies are suing the federal government while passing these charges onto consumers. Litigation, consumer confusion, and partisan squabbling in Congress over the e-rate threaten to stall or even roll back what has been an impressive start in getting schools wired for the 21st century. We need to support, not scuttle, the effort to get our classrooms wired, and make sure we move forward to close, not perpetuate, the digital divide. ▶

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Advertisement

Teacher Training - The Critical Ingredient

This year, schools will spend nearly 15 times as much on computers and Internet connections as on training teachers to use the high tech tools. And yet, a recent Market Data Retrieval study found that 61 percent of teachers felt either "not at all prepared" or only "somewhat prepared" to integrate technology into classroom instruction.

The economy of the future depends on the quality of education in our classrooms and the ability of our students to compete in an increasingly technical world. Our teachers are a critical element in ensuring that our students are as competent using these high tech tools as they are using pencils, paper and textbooks. Teachers can be powerful role models by encouraging students to understand the impact of technology and how to use it to affect positive change.

Three things are critically important to ensure that teachers use technology effectively. First, teachers need direct access to the Internet in their classrooms. Second, teachers need to learn how to integrate technology into their curricula, not simply receive training on computer skills or practice using applications. And finally, teachers need technical support to keep their computers and networks up-to-date and running reliably.

Technology has great potential to improve learning. It can provide real educational benefits by increasing productivity and global awareness, and by helping to make instruction more individual and specific to the students' needs. But none of this happens magically. Profound change will only happen if we provide our teachers the resources they need to use this technology effectively to improve the learning process. Our children depend on us to make this happen.



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A MILLENNIUM-YEAR SPECIAL SECTION

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Indispensable Inventions

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1959 ALKALINE BATTERY

THE FIRST batteries for consumer use appeared in the late 19th century. Within a few decades, carbon-zinc dry cells made it possible to produce small, battery-powered devices like radios and flashlights. But in 1959, carbon-zinc batteries still didn't last long enough for many envisioned applications. Eveready Battery Co. researcher Lew Urry thought his prototype alkaline battery might do the trick, but it took a hands-on demonstration to convince a company executive, who was told to leave two flashlights turned on in his desk drawer overnight—one with a carbon-zinc battery and the other with Urry's prototype. In the morning, only the alkaline was still shining. Today, Americans spend \$1.3 billion per year on alkaline batteries.



1268 CORRECTIVE LENSES

ENGLISH MONK Roger Bacon made the first recorded observations about the use of lenses for vision correction: In 1268, he pointed out that glass lenses could magnify letters on a page. But eyeglasses may have already been invented in China. In 1275, Marco Polo reported that the Chinese were reading with the aid of lenses held in place by weighted cords hung from the ears. The first bifocals were made in 1784 for Benjamin Franklin, and contact lenses were invented in 1887.

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1967 QUARTZ WATCH

IN THE EARLY 1920s, a scientist named W. G. Cady discovered that quartz crystals could be made to vibrate at a steady rate when placed in an electrical circuit. What's more, Cady learned, the frequency of the vibration could be controlled by cutting the quartz in a specific way. Building on Cady's work, researcher Warren Morrison of Bell Telephone Laboratories used a vibrating quartz crystal to devise a clock that was far more accurate than any mechanical timepiece. A miniature version of Morrison's vibrating crystal made it possible to create the first quartz wristwatch in 1967.

**1920 ADHESIVE TAPE**

TWO-TONE CARS were popular in the early 1920s, when 3M researcher Dick Drew overheard workers in a body shop cursing the heavy adhesive tape and butcher paper they were using to paint a car. The tape peeled away paint, requiring extensive touchups. Drew set about developing a tape with less aggressive adhesive, the first masking tape. 3M's president wouldn't approve funding for the project, but Drew forged ahead anyway, disguising his work in a flurry



of small purchase orders. A few years later, Drew invented cellophane tape. During World War II, Johnson & Johnson added a waterproof coating to its medical bandaging tape—creating duct tape, now reputed to hold the world together. The tape got its name and silver color during the post-war housing boom, when it was used for duct work.

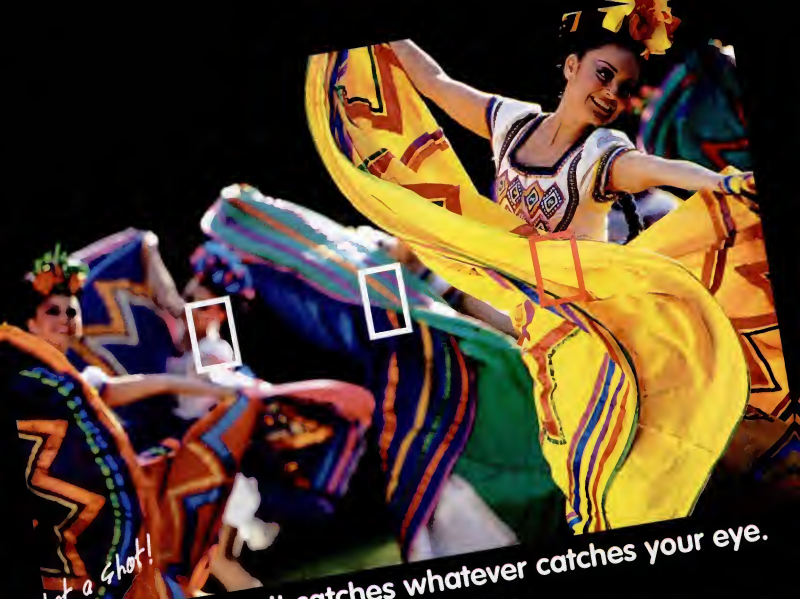
1879 INCANDESCENT LAMP

THOMAS EDISON'S light bulb was not the first invented, but it was the first to gain wide acceptance. Edison and his colleagues experimented with thousands of filament materials and bulb designs while they were trying to develop a replacement for oil and gas lighting. Finally, in 1879, they electrified a carbonized cotton thread inside a fragile glass bulb from which all the air had been removed. The lamp glowed for 13 hours before its filament failed. Modern light bulbs use tungsten filaments, which last longer.

**1893 ZIPPER**

WHEN A FRIEND had difficulty tying the laces of his boots, Chicago inventor Whitcomb Judson designed a "clasp locker" that today is recognized as the first zipper. Judson displayed his prototype at the Chicago World's Fair in 1893, but it jammed easily and sold poorly. Two decades later, Swedish-American engineer Gideon Sundback developed an improved version. B.F. Goodrich coined the onomatopoeic name "zipper" in 1923 when the hookless fastener was featured on its new galoshes.





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1888 BALLPOINT PEN

AN AMERICAN leather tanner named John Loud invented the first pen to apply ink with a rolling ball; he used it for marking hides. Many variations followed, but most suffered from leaks and clogs. The first successful version was patented in 1938 by Hungarian brothers Lazlo and Georg Biro, who devoted much effort to developing a quick-drying, smooth-flowing ink. Their design was later refined by Frenchman Marcel Bich, who introduced the inexpensive Bic pen, still known in England as the Biro. Some 14 million are sold daily.

1942 TUPPERWARE

IT WAS DuPont chemist Earl Tupper who took a new plastic formulated by his company in 1942—polyethylene—and turned it into colorful lidded bowls and other household storage products that could be “burped” to minimize spoilage. Other manufacturers followed Tupper’s lead, creating resealable plastic containers such as the Rubbermaid cereal saver shown here. But only Tupperware became a household word, through a unique marketing strategy in which products are sold at parties hosted by volunteers for their friends and neighbors. Today a demonstration starts somewhere in the world every two seconds, the Tupperware Co. claims.



1899 PAPER CLIP

OFFICE MANAGERS of the 13th century fastened papers together with short lengths of ribbon woven through cuts in the upper lefthand corner of the sheets. Today we use small curved lengths of metal shaped into paper clips, the most successful variation of which is the double-oval Gem clip. The paper clip’s invention is credited to Norwegian Johan Vaaler. Since Norway had no patent system, Vaaler filed for patent rights in Germany in 1899. Norwegians wore paper clips on clothing during World War II to show their patriotism.

1948 VELCRO

SWISS ENGINEER George de Mestral returned from walking his dog one day to find cockleburrs stuck to his clothing and pet. Examining one under a microscope, he saw that its surface was studded with tiny hooks. That gave him an idea for a new type of fastener made from two strips of fabric—one with hooks and the other with small loops—that bond tightly when pressed together. De Mestral called his product Velcro, from the French words “velour” and “crochet.”





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¹Based on AMCI-certified performance tests conducted using a model-year 2000 Toyota Tundra V8 Access Cab Limited against comparably equipped 1999 5.4-liter Ford F-150, 5.3-liter Chevrolet Silverado and 5.9-liter Dodge Ram half-ton full-size 4x4 V8 pickup trucks with 1,200 lbs. of payload.

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NEWSFRONTS

SCIENCE & TECHNOLOGY

EDITED BY DAWN STOVER

EXPLORATION

Arctic Outpost

TO PREPARE for exploration of the Red Planet, scientists are building a simulated Mars base on Devon Island—a barren, windswept, uninhabited outpost high in the Canadian Arctic. The Mars Society, a private organization devoted to establishing a human presence on Mars, has already raised about \$225,000 to finance the new facility, which will support an ongoing NASA research program on the island.



The Mars Arctic Research Station (MARS) will be ready for human occupants next summer. It will be built inside Haughton Crater, a



Astronauts exploring Mars could someday live in a habitat similar to this base station (above), which will be built in the Canadian Arctic. The station will have facilities for eating, sleeping, exercise, and research (left). It will be unpressurized, with a simulated air lock.

giant cavity formed some 23 million years ago when an asteroid slammed into Devon Island. Impact craters are common on Mars, and the site has a number of other Mars-like features, according to Pascal Lee, a planetary scientist at the NASA Ames Research Center who heads

the project. Haughton Crater is a polar desert cut by valleys that bear an astonishing resemblance to valleys observed on Mars, Lee says.

The base will house a crew of four to six people, and support their research activities, in a two-story cylinder with a domed top. The idea is to test equipment, as well as living and working arrangements, "to determine the best way for humans to explore Mars," Lee says.

Although there is no current NASA mandate to send humans to Mars, Lee believes a mission could be launched within a decade of government approval. "What we're doing in Haughton Crater is a low-key, low-budget feasibility study to help us get ready." Exploration of the crater should also improve our understanding of Earth.—Steve Nadis

MEDICINE

Resistance on the Rise

IT'S NOT QUITE the Andromeda Strain—yet. But a recent outbreak of infectious disease on the northern plains has doctors worried. Four children in Minnesota and North Dakota have died from *Staphylococcus aureus* bacteria resistant to methicillin, a powerful antibiotic. That's not so rare. What frightens physicians is

that the children never visited a hospital or nursing home, nor were they exposed to anyone who had.

Antibiotics have been losing their effectiveness for years ["Superbugs," May]. But resistant bacteria have mostly been confined to health care facilities. The four children's deaths mean that these dangerous organisms are now at large in the Midwest.—Mark D. Uehling

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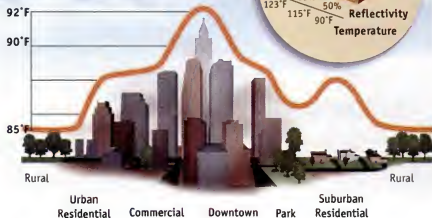
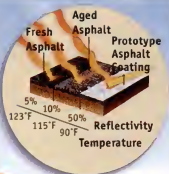
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SCIENCE & TECHNOLOGY

An urban downtown with few trees and many paved surfaces is a "heat island," with higher temperatures than surrounding suburban and rural areas (below). Whiter surfaces can help keep cities from overheating. For example, a prototype white asphalt coating is more reflective and stays cooler than conventional asphalt (right).



ENVIRONMENT

Heat Islands

IT'S NO SECRET that cities are generally warmer than the countryside around them. Not only do urban areas have fewer shade trees, but they also have more heat-absorbing surfaces such as roofs and pavement.

To help urbanites beat the heat, researchers in the Lawrence Berke-

ley National Laboratory's Heat Island Group advocate replacing dark surfaces with lighter colors. Whiter roofs, for example, could save \$37 million per year in energy costs for Phoenix, the researchers estimate. Even in cities farther north, reduced cooling costs would outweigh any extra heating bills associated with whiter roofs. Cooling cities has the added benefit of reducing smog, the researchers point out.—D.S.

NATURE

For the Birds

LINKING WINTER habitat to breeding success has been called the Holy Grail of songbird biology. Until recently, bird biologists relied on information from the leg bands of migratory songbirds—which is scanty at best.

Now scientists have a new tool for determining where a bird has been. Birds' feathers and blood carry the distinctive ratios of stable isotopes from their environment. A stable isotope is a naturally occurring atom with a different atomic weight than other versions of the same element. Scientists can read the isotopic sig-

natures using a mass spectrometer, which separates and counts atoms of each weight.

Already scientists have used the technique to show that American redstarts wintering in poor habitats don't breed as successfully come summer as those wintering in rich habitats. They've also learned that one population of willow warblers turns east at the Alps during its southward migration from Sweden, while another turns west and winds up in a different part of Africa.

Like bird banding, carbon and hydrogen isotope analysis can be done harmlessly.—Madeline Bodin

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FAST FORWARD



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Paleontologists Judd Case and Dan Chaney collect dinosaur remains on the Antarctic peninsula.



DINOSAURS

A Missing Link

WHEN THE AGE of dinosaurs began, Earth's continents were fused together into a vast supercontinent known as Pangaea. Paleontologists have generally agreed on how the breakup of Pangaea resulted in the continents of today. But the discovery of a partial dinosaur skeleton in Antarctica now casts doubt on the details and may revolutionize our picture of the Mesozoic world.

The dinosaur, discovered in February by an Argentine team, was found on the Antarctic peninsula, an arm of the continent stretching toward South America. Paleontologists say the 4-meter-long creature is a relative of *Iguanodon*, progenitor of the "duck-billed" dinosaurs, or hadrosaurs. Only a few dinosaurs have been found in Antarctica, and this is only the second hadrosaur found there. The first hadrosaur was unearthed by a National Science Foundation team in 1998.

Paleontologist Jim Martin of

South Dakota's Museum of Geology, who identified the 1998 fossil, says he and his colleagues did not expect to find a hadrosaur in Antarctica. "It would have been the last place I looked," Martin says. The reason, he explains, is that scientists have long assumed that Antarctica separated from North and South America during the breakup of Pangaea, tagging along with the southern supercontinent Gondwana. Hadrosaurs originated in North America, so how did these land-dwelling herbivores cross hundreds of miles of ocean to reach Antarctica?

To Martin and colleagues Judd Case and Mike Woodburne, the presence of hadrosaurs in Antarctica can mean only one thing: A land bridge remained between the Americas and Antarctica during much of the Mesozoic era. This bridge may have served as a migration route not only for dinosaurs, but also for birds and marsupials that could have ranged as far as Australia.—*Michael Carroll*

SPACE

Orbs in Orbit

IN ABOUT TWO YEARS, NASA astronauts will go into space with personal assistants. Robotic assistants, of course. About the size of softballs, these personal satellite assistants (PSAs) can float throughout the space shuttle or space station, automatically monitoring life support systems, snapping photos, and taking over monitoring tasks from failed sensors. They're equipped with collision avoidance systems so they won't bump into anything. Naturally, they're wireless.

Thanks to their videoconferencing capabilities, the PSAs offer a virtual presence for ground crews and scientists, letting them advise astronauts—in real time—in the midst of their experiments. The PSAs will be stowed

until the spacecraft reaches orbit, and then activated by the astronauts, ground crews, or even by the spacecraft itself or other PSAs requesting help. They can work automatically or respond to voice or radio commands, and can exchange information with the spacecraft's main computers.

Floating through the spacecraft, the little robots will measure gas levels, temperature, and atmospheric pressure—making them ideal for checking alarms and dangerous areas, such as the compartment that caught fire on the Mir space station. And, if "smart" identification tags are added to inventory items like food pouches and experiment samples, project manager Yuri Gawdiak of NASA's Ames Research Center says PSAs could track inventories,



One of their biggest benefits may be size. By squeezing into hard-to-reach spaces of the shuttle or space station, PSAs can go where no man has gone since the vehicles were first assembled—simply because man doesn't fit.—*Gail Dutton*



Yuri Gawdiak is developing a "personal satellite assistant" to help astronauts do their work.

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40	\$ 123	\$ 158	\$ 185	\$ 238	\$ 260
45	\$ 190	\$ 215	\$ 253	\$ 330	\$ 385
50	\$ 253	\$ 290	\$ 363	\$ 490	\$ 495
55	\$ 365	\$ 413	\$ 550	\$ 835	\$ 1,015
60	\$ 503	\$ 615	\$ 845	\$ 2,135	\$ 2,400
65	\$ 775	\$ 975	\$1,593	\$ 3,900	\$ 3,900
70	\$1,338	\$ 1,600	\$2,970	\$ 7,220	\$ 7,220
75	\$2,275	\$ 4,870	\$5,820	\$10,370	\$12,420

Male Premiums

Age	10 YEAR	15 YEAR	20 YEAR	25 YEAR	30 YEAR
35	\$ 123	\$ 138	\$ 165	\$ 223	\$ 253
40	\$ 148	\$ 183	\$ 225	\$ 288	\$ 335
45	\$ 225	\$ 300	\$ 360	\$ 450	\$ 513
50	\$ 338	\$ 455	\$ 525	\$ 743	\$ 828
55	\$ 500	\$ 670	\$ 768	\$ 1,640	\$ 2,330
60	\$ 783	\$ 990	\$1,335	\$ 3,630	\$ 3,630
65	\$1,330	\$ 1,650	\$2,693	\$ 5,250	\$ 5,250
70	\$2,473	\$ 3,175	\$4,860	\$ 8,790	\$ 8,790
75	\$4,400	\$ 7,443	\$9,600	\$13,260	\$15,030

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AUTOMOTIVE

EDITED BY DAN MCCOSH

PREVIEW DRIVE



Aerodynamics dictate the insight's shape, including such features as full rear skirts.

Insightful Hybrid

WHEN IT GOES on sale this month, Honda's new hybrid-drive Insight, at more than 70 miles per gallon, will be the most fuel-efficient car you can buy in the United States. (The world leader is Volkswagen's 3.0-liter Lupo diesel, on sale in Europe, which gets around 78 mpg.) It also earns bragging rights as the first hybrid here, artfully beating Toyota's Prius, which is already on sale in Japan.

The fuel savings come from the Insight's ultra-efficient drivetrain and ultra-lightweight aerodynamic body. That's no small feat, but you pay in storage space—the tiny two-seater has only minimalist accommodations for an overnight bag. The body structure of the Insight is similar to the all-aluminum Acura NSX, constructed of sheetmetal, welded extrusions, and castings. It exceeds contemporary crash standards, but Honda engineers say it is expensive to repair. Still, with a 1,856-pound curb weight (without air conditioning), it is among the lightest cars on the road today.

The powertrain consists of a tiny three-cylinder 67-horsepower lean-burn engine that under most circumstances turns itself off when you stop the car. It restarts when the gearshift

is engaged, via a crankshaft-mounted starter-alternator that also supplies additional torque under acceleration. The combined electro-piston powertrain uses a nickel-metal-hydride battery to capture and store energy produced while braking, further improving efficiency. The lean-burn engine also requires a specialized catalyst to reduce nitrous oxide emissions, which Honda says works well despite the fact that U.S. fuel contains high levels of sulfur, which typically punishes such devices.

The overall performance, with an estimated 0-to-60-mph time of about 12 seconds, is lively but not head-snapping either. The engine shifts from electric to gas mode seamlessly most of the time, but some shifts are felt in the driveline. And it's disconcerting when the engine shuts off at a stoplight. During a test drive in northern Virginia horse country, the lightweight car was agile, but the narrow, high-efficiency tires and heavy front weight prompted some nervous twitching while entering corners.

Honda says it will lose money at the under-\$20,000 price tag of the Insight, but is willing to put it on the market to gain experience and to gauge buyer reaction. As a gas-sipping commuter car, it has no current peer.—D.M.

HANDS ON

Puncture-Proof Tires

NEW RUBBER materials and design techniques are trickling from the tread to the sidewall in Goodyear's first new off-road tire in a decade, the Wrangler MT/R.

Silica, used in recent tires to extend tread life and improve grip, now adds durability to the sidewall of the Wrangler MT/R as well. The silica is suspended in the same polymer chains that also hold the tire's usual carbon black molecules. Both silica and carbon black act as reinforcement to the rubber compound. Silica provides triple the tear resistance of carbon black, the company says. During a hard day on the Rubicon Trail in California, scraping the tires against sharp rocks inflicted no apparent damage.



Silica in the rubber compound and a multiple-layer sidewall enhance the new Wrangler's resistance to puncturing during hard off-road trekking.

Heavy tread lugs wrap around onto the sidewall for further protection against bumps and scrapes. The tires' straight-line stability is good, with no annoying wandering. The grip on gravel, snow, and wet pavement is all greatly improved over the previous tire.

On the road, the new tire shows its polish as well: The Wrangler MT/R is surprisingly quiet for a tire with such heavy tread. Best yet, the enhancements have boosted tire life a startling 74 percent over the previous model.—Dan Carney



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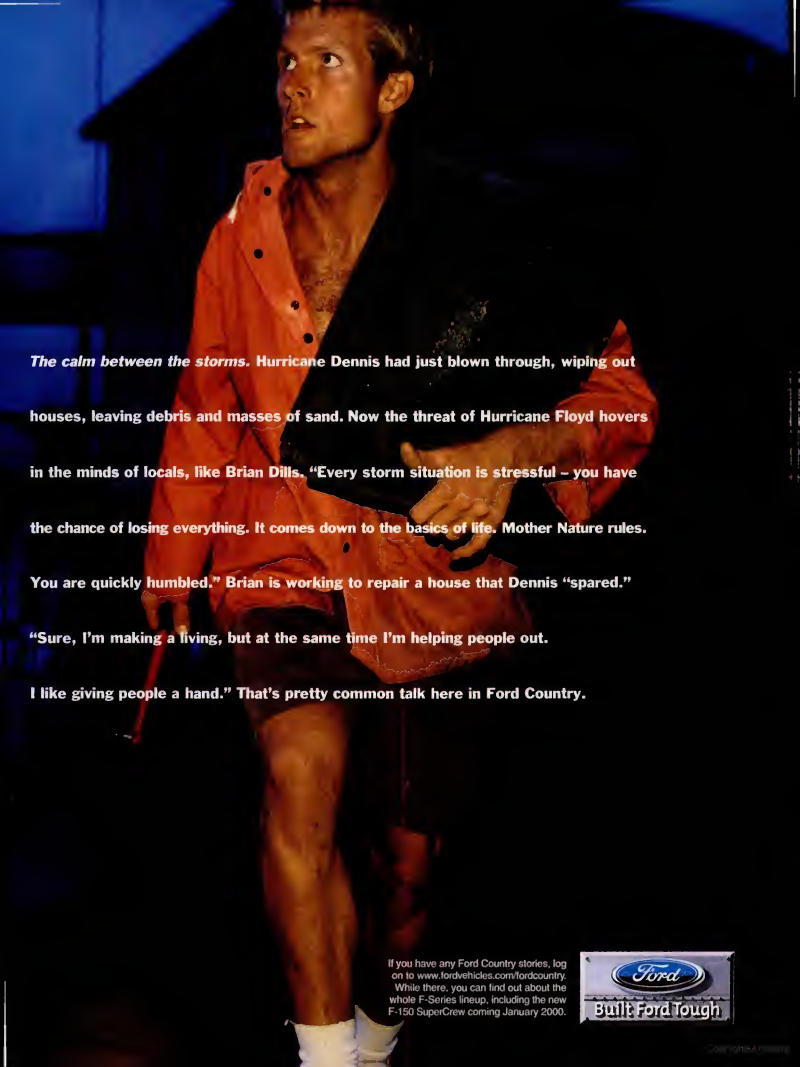
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Photographer's notes: "My assignment was to record life as it happens in 'Ford Country.' Brian Dills owns one of the many Ford trucks that were scattered along the beach, working between storms. Brian drives an F-350 turbo diesel. The sand was pushed in from the ocean, so only 4x4s could get out to the house." - David Alan Harvey

Outer Banks North Carolina **Ford Country** Sept. 9, 1999 7:20 p.m.



The calm between the storms. Hurricane Dennis had just blown through, wiping out houses, leaving debris and masses of sand. Now the threat of Hurricane Floyd hovers in the minds of locals, like Brian Dills. "Every storm situation is stressful - you have the chance of losing everything. It comes down to the basics of life. Mother Nature rules. You are quickly humbled." Brian is working to repair a house that Dennis "spared."

"Sure, I'm making a living, but at the same time I'm helping people out. I like giving people a hand." That's pretty common talk here in Ford Country.

If you have any Ford Country stories, log on to www.fordvehicles.com/fordcountry. While there, you can find out about the whole F-Series lineup, including the new F-150 SuperCrew coming January 2000.



PREVIEW DRIVE

Room for Improvement

YOU DON'T MESS with a good thing, especially when the good thing is as successful as the Ford Taurus. But even the Taurus, one of the best-selling midsize sedans of the past decade,



The Taurus gets a raised roofline at the rear, improving rear-seat headroom and trunk space.

wasn't immune to improvement. So for model-year 2000, Ford gives its customers a roomier back seat and trunk.

The 2000 Taurus features a raised roof line, which improves headroom and allows for a larger rear door. Not exactly a dramatic change—more the kind of finessing done nervously to a known quantity, where the probability of making an error seems to outweigh the odds of making a noticeable improvement.

Dynamic changes are likewise subtle—improved power for both the base 155-horsepower 3.0-liter V6 and the optional 200-horsepower 24-valve 3.0-liter V6. The suspension is softer but

body roll is reduced, as demonstrated on a quick tour through the Virginia countryside near Washington, D.C. Steering is precise and responsive, with the chassis dutifully following with little drama or excitement.

The new Taurus also adds a comprehensive safety system, which consists of pretensioning devices on the seatbelts, optional side-impact airbags, and a complex system of determining crash severity and seating position to optimize the strength of airbag deployment. A formal switch panel replaces the ergonomic oval in the interior of the previous car. The result is a smooth, roomy sedan that finds itself near the dead center of the industry, unlikely to offend or irritate. Prices start at \$18,245.—D.M.

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FUEL ECONOMY

Gang Green

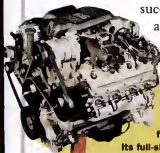
COMPARE YOUR CAR with the EPA's list of the most fuel-efficient gas vehicles in each class.—D.M.

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Compact		
Toyota Corolla	Manual	31/38 mpg
Midsize		
Dodge Stratus	Manual	26/37 mpg
Plymouth Breeze	Manual	26/37 mpg
Large		
Chrysler Concorde	Automatic	21/30 mpg
Dodge Intrepid	Automatic	21/30 mpg
Minivans		
Dodge Caravan 2WD	Automatic	20/26 mpg
Plymouth Voyager 2WD	Automatic	20/26 mpg
Pickup Trucks		
Toyota Tacoma 2WD	Automatic	21/24 mpg
Sport-Utility Vehicles		
Suzuki Vitara 2WD	Automatic	25/27 mpg

* Of all gasoline cars and trucks. Diesel-powered vehicles not included.

ENGINES
Pickup Power

DIESELS can't be beat when heavy loads and long-haul durability are of concern. To catch up with the success that Dodge and Ford have enjoyed, General Motors has



GM's new direct-injection diesel improves fuel economy in its full-size trucks.

introduced a new engine and transmission engineered for tough towing and hauling applications.

The Duramax 6600 Diesel, which was developed in cooperation with Isuzu Motors, is a 6.6-liter turbo-charged and intercooled V8 featuring aluminum cylinder heads. An electronically controlled Bosch common-rail direct fuel-injection system minimizes smoke, noise, vibration, and exhaust emissions. Output ratings won't be announced until this engine goes into production for the 2001 Chevrolet Silverado and GMC Sierra pickups, but competitive test drives suggest that more than 300 horsepower and 500 pound-feet of torque are available.

The new diesel V8 is teamed with a five-speed automatic transmission. An electronic control module commands shift sequences and torque-converter lockup with closed-loop, adaptive-learning capability to change the way the clutch engages depending on your driving style. This transmission automatically downshifts on steep grades to provide extra engine braking.

The fact that this new diesel power team works hard without raising a ruckus should be the best news of all for heavy-duty diesel pickup fans.—Don Sherman


No-Draggin' Wagon

I'M DRIVING BMW's new 328i sport wagon in the Bavarian countryside outside Munich, Germany. Soon, I maneuver the wagon onto a speed-obsessed autobahn. Don't think a wagon can keep up? Think again. Within a few seconds, I'm cruising at 100 mph like I was born there. A few minutes later, I move into the left lane to pass a truck. The vehicle is rock steady at 125 mph. If I didn't know any better, I'd swear I was in a sport sedan.

The 328i I'm driving as a test vehicle has about 10 percent more horsepower (193) than the six-cylinder version that will come to the United States next spring for about \$30,000. But if you think the sport wagon will be substantially different than any of the other popular 3 Series cars in the BMW lineup, you're mistaken. The wagon is identical to the sedan in nearly every respect—except, of course, in the rear. And the suspension has been tweaked to carry a heavier load than the sedan.

A long wheelbase of 107.3 inches makes for a stable ride on and off the autobahns. Inside, the appointments are luxurious but not at the expense of cargo room. The rear seats split for even more space. The rear window and door can be opened independently to make getting things in and out of the vehicle easy.—Frank Vizard

The all-new and smooth-running BMW sport wagon differs from the notchback 3 Series only in appearance.

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ELECTRONICS

EDITED BY SUZANNE KANTRA KIRSCHNER

AUDIO & VIDEO

Sneak Preview 2000

EVERY TWO YEARS, the largest audio-video show in the world is held in Berlin. This fall, everyone at the Internationale Funkausstellung was talking about interactive TV ["Talk TV," November], but the aisles were also full of products that will likely appear in the United States next year. Here are the highlights from the show.—Frank Vizard



▼ TWO-FOR-ONE VCR

JVC's HR-DVS1 is the first dual-deck VCR to offer digital and analog video playback in one box. It has both a MiniDV (the tapes used in many digital camcorders) and a Super VHS slot. This makes playback of MiniDV digital tapes much easier—and copying to Super VHS tape a cable-free operation.

▼ RECORDABLE DVD PLAYER

DVD video recorders should arrive in the United States in the second half of next year. This Philips prototype DVD video recorder-player stores as much as 4.7 gigabytes on a single disc. That's about 2 hours of DVD-quality video or 4 hours of VCR-quality video.



▲ INTERNET-SAVVY FAX

The fax machine joins the Internet revolution with this Philips model that offers built-in e-mail capability. You can even call up and print out Web pages by typing in their URL addresses on the unit's keyboard.



◀ VOICE-OPERATED TV/VCR

The day's not far away when you'll be able to control your TV and VCR with just your voice. Thomson (RCA in the United States) has built the NaviVox voice recognition system into a remote control. You just press a button and issue your command. The TV "hears" what you want via an FM radio transmission.

(Continued on next page)



Sneak Preview 2000

(Continued from previous page)

▼ STYLISH MP3 PLAYER

Philips will join the ranks of companies offering MP3 devices, which play music downloaded from the Internet, with style. The distinctively square-shaped SA101 has a removable 32MB flash memory card and includes an equalizer for adjusting sound quality. Its display shows song, artist, track number, and elapsed time.



▲ DESIGNER AUDIO

High style comes to small desktop audio systems, such as this Sony CD/radio combination. The dominant visual element, a glass panel that reveals a vertically mounted CD player, is set against a cherry wood finish. With a 12-watt-per-channel amplifier, this system should sound as good as it looks.

► TV/DVD COMBINATION

As DVD players drop in price, combining them with televisions makes for a natural space-saving evolution of the technology, as this model from Thomson (RCA) demonstrates.



HDTV

Better Eye Candy

TO MOST PEOPLE, the year-old digital TV system represents visual perfection. But in some quarters, namely the big screen, that same quality is far from perfect.

This may not seem like a big deal today, while movies are still delivered on film. But the future of cinema may lie with delivering high-definition signals over the air, a fact underscored this summer when Lucas Arts experimented with digital screenings of *Star Wars: Episode I*.

The problem: The current 1080i (or

1,080 interlaced lines) standard for HDTV delivery, while fine for a typical living room, creates telltale black scan lines across theater-size screens. Changing the specification to 1,080 progressively scanned lines (1080p) would solve the problem, but that's easier said than done. A 1080p signal has twice the resolution of 1080i and would require more bandwidth to broadcast the signal than the 6MHz allocated to HDTV today.

But there is hope, and all that's required is a little sleight of hand. Matsushita, the parent company of Panasonic, proposes that the main

body of HDTV information arrive at the theater via a regular broadcast of 720 progressive lines of HDTV resolution and that the additional 360 lines of resolution (equaling 1080p) be furnished simultaneously by satellite or a fiber-optic phone line transmission. The information from the two signals would then be combined at the theater.

Matsushita's plan for over-the-air HDTV movie distribution could eventually be applied to home theaters as well, although current HDTV sets are not capable of displaying 1080p digital signals.—Stephen A. Booth

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Electronics With 9 Lives

JAPAN IS getting tough about recycling—and not in the paper and plastic kind of way. Starting in 2001, the country will require that all electronics goods—TVs, VCRs, stereos, and more—be recycled. But recycling won't be left to consumers; instead, the devices will be sent to the original manufacturer for proper disposal.

The new law poses a few challenges to manufacturers, who are now rushing to set up collection networks and perfecting techniques to disassemble and recycle older products. With an eye toward the future, they are also integrat-



RECYCLING

ing easily recycled materials into new products.

Plastics, a major component of most electronics products, pose a particular hurdle because they degrade with age, losing strength and flexibility even if reprocessed. NEC Corp. overcomes this problem by creating a plastics sandwich, in which the filling is 100 percent recycled plastic and the outer layers a mixture of 14 percent recycled material. The resulting plastic has sufficient strength and toughness for use as a casing for desktop PCs. The company, in cooperation with plastic resin maker Sumitomo Dow, has also developed a new silicone polycarbonate plastic, which engineers claim retains

its mechanical properties through repeated recycling. NEC uses the plastic, which is also flame-retardant, in battery cases for notebook PCs.

Meanwhile, Matsushita Electric, maker of the Panasonic brand, is eschewing plastic in favor of magnesium. Magnesium, says the company, is ideal for recycling because it retains its original strength through repeated reprocessing. Matsushita has developed molding techniques to form magnesium into the case for a 21-inch TV. Unfortunately, the magnesium case and energy-saving features make the TV about twice as expensive as an ordinary model. The company hopes, however, that increased use of magnesium will eventually bring prices down.—Dennis Normile

COMMUNICATIONS

Low-Maintenance Cellphones

THE NIGHTLY RITUAL of popping your digital cellphone into a charger may soon become a monthly one. The extra time comes from Analog Devices' Othello mobile phone radio chip set, which requires less power than other radio chip sets.

The power savings come from the way the Othello turns radio signals into digital voice and data signals. As a radio signal comes in, it's converted from the higher transmission frequency (900- to 1,900MHz) to 1- or 2MHz, a frequency that enables the phone to convert the signal easily into the ones and zeros of digital communications. It's this conversion that sucks up so much power. Con-

ventional mobile phones use multiple steps to accomplish this conversion. But the Othello needs just one, dramatically reducing the electricity needed to power the phone.

The additional power can also be put to other good uses, such as high-

speed data services. Analog Devices Othello radios can support data rates up to 400 kilobits per second (Kbps).

To get extended battery life, you won't have to wait long. Othello radios will be built into Siemens' digital GSM phones next year.—S.K.K.

Beefing Up Battery Life

IF YOU HAVE the gift of gab, Analog Devices' Othello radio may not help much with battery life. That's because radio transmission consumes the most power in standby mode. Here's how Othello stacks up against other cellphones:

TYPE OF CELLPHONE	AVERAGE TALK TIME	AVERAGE STANDBY TIME	DATA SPEED
Analog/CDPD*	45 to 90 minutes	12 to 20 hours	19.2Kbps
Digital PCS	70 to 240 minutes	24 to 60 hours	14.4Kbps
Othello	70 to 240 min. plus	1,000 hours	400Kbps**

* Cellular Digital Packet Data ** Approximate speed

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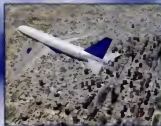
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COMPUTERS & SOFTWARE

EDITED BY FRANK VIZARD

INTERVIEW

Conversation with Carver Mead

NEUROMORPHIC electronic systems are circuits modeled after living nervous systems. This is just one area of study for Carver Mead, this year's winner of the \$500,000 Lemelson-MIT Award for invention and innovation. Mead, a 40-year professor of engineering and applied science at the California Institute of Technology, is noted for his work in computer chip design and microwave communications. Mead started his education in a backwoods school in the Sierra Nevada Mountains that had only 20 students and two teachers. He now holds 50 patents.—F.V.

ON COMPUTING: "Computers today can churn data at alarming rates, but getting data into the computers is still a problem. Visual, sound, and



touch data—a huge amount—is coming in, and we don't have any computers that can deal with all that data in real time. We're light-years ahead on the output side, but on the input side we are in the Stone Age."

ON FUTURE COMPUTERS: "There is no question that information machines are going to have senses in the same way as living animals."

ON SPECIALIZATION: "I think training our children to be specialists is the

wrong thing to do. If specialization continues, then you risk losing cross-fertilization, which is where all the innovation is."

ON INNOVATION: "We have to spend a lot more energy on simplifying things, because if we don't we're going to lose our ability to innovate. Innovation, after all, comes from seeing the common roots [among different disciplines]."

THE NEXT AREA OF INNOVATION: "Neuroscience. This digital stuff we do is just one brain-dead way of processing information. There are probably much smarter ways of doing it. The only real examples we have of these smarter ways are in living organisms. But we know so pathetically little about this, we don't even see it as computing. I also have a sense that every day, people will be dealing with superconducting objects. I want to see how that develops."

ROBOTICS

Body Building

FOR ALMOST A CENTURY, engineers have been trying to build robots using straightforward mechanical and electrical design principles. All they have succeeded in creating are electronic puppets that work well only when a human is pulling the strings, claims Jordan Pollack, an associate professor of computer science and complex systems at Brandeis University. To give these robots true minds of their own, he says, would require "a bigger program than even Microsoft can write."

Instead, Pollack and his colleagues are testing a bottom-up approach—letting robots design themselves. In the animal world, bodies and brains have evolved in lockstep over millions of years, Pollack points out. That type

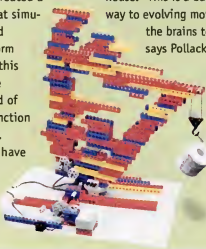
of evolution may be possible for robots as well, he says. And it may produce robots that are cheap enough to be disposable.

But since there isn't time to build and test generation upon generation of hardware, graduate researcher Pablo Funes instead created a computer program that simulates robot bodies and evolves them to perform certain functions. In this case, the "bodies" are structures—composed of Lego blocks—that function as bridges and cranes.

Pollack and Funes have built some of the structures specified by the computer's trial-and-error ap-

proach, and they turned out to be surprisingly sound. For example, the program "discovered" a cantilever bridge design that took humans centuries to invent.

But it's still a long way from a Lego bridge to a robot that can clean the house. "This is a baby step along the way to evolving moving bodies and the brains to control them," says Pollack.—Dawn Stover



An "evolutionary" computer program designed this crane, made of Lego blocks, without any help from humans. The program came up with an inverted triangle design familiar to engineers.

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INTERNET

'It's An Addiction!'

FIND IT HARD TO STOP surfing the Net? Spouse complaining that you disappear into the computer? Kids don't recognize you anymore? You may be a victim of Internet addiction, a problem as tough to beat as being hooked on drugs, alcohol, or gambling.

Psychologist Kimberley S. Young, founder and CEO of the Center for Online Addiction in Bradford, Pennsylvania, has conducted the first study to examine the pathological use of the Internet. The study analyzed the behavior of 496 heavy online users against the criteria used to classify pathological gambling. These two dependencies closely resemble each other in the inability of the addicted to control impulses, without necessarily involving any addictive substance. For the purposes of the study, the Internet was defined as any online system or network. People who were active users were eligible to participate.

Of the subjects, 239 women and 157 men were classified as dependent. Among the criteria used to confirm this diagnosis (at least four out of 10 were needed): lying to

family members about how much time was spent online; increased depression or anxiety when offline; inability to control Internet use; and persistent use even after spending too much money on online fees.

Young says that those subjects classified as dependent "exhibited significant addictive behavior patterns. We also discovered that the use of the Internet can disrupt one's academic, social, financial, and occupational life the same way other well-documented addictions like pathological gambling, eating disorders, and alcoholism can."

The greatest incidence of Internet addiction, Young reported to the annual meeting of the American Psychological Association, occurred among middle-aged women and currently unemployed men and women.—Arthur Fisher

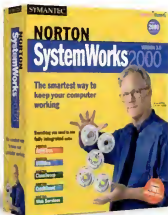
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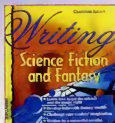
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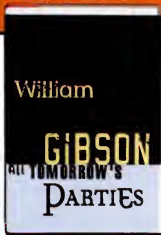
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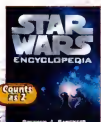
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HOME TECHNOLOGY

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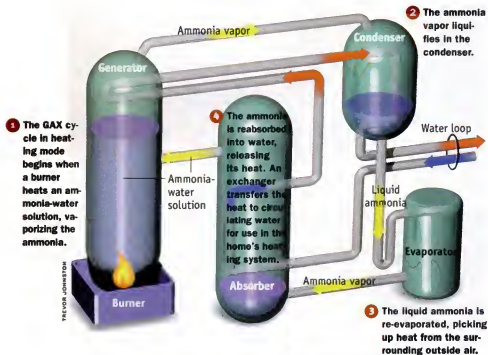
HEAT PUMPS

Pumping with Gas

IF A NEW heat pump technology catches on, you may be able to slash your heating and cooling bills by half that of the most efficient units now available. Developed by Phillips Engineering in St. Joseph, Michigan, and the Oak Ridge National Labora-

tory, the Generator Absorber Heat Exchange, or GAX, unit runs on natural gas rather than electricity.

A heat pump's job is to move heat from inside to outside in the summer, and vice versa in winter. In an electric unit, a halogenated refrigerant is evaporated at low pressure, absorbing heat from the surrounding air. A compressor then raises the refrigerant's pressure and temperature.



Finally, the hot vapor moves to a condenser, where it re-liquefies and sheds the heat it gained earlier. Unfortunately, the electric heat pump has two major drawbacks: the compressor burns lots of electricity, and the halogenated refrigerant attacks the Earth's ozone layer.

GAX eliminates the refrigerant and the compressor. Instead, in the heating mode, a gas-driven generator heats an environmentally benign ammonia-water solution, vaporizing the ammonia. The ammonia is liquefied in a condenser, then re-evaporated, during which it picks up heat from the surrounding air. The liquid ammonia is then absorbed back into the ammonia-water solution, where it gives up its heat to water circulating through the heating system. The water picks up even more heat as it moves through the generator and condenser. The GAX uses 50 percent less energy in heating mode than a high-efficiency gas furnace. The process is reversed for cooling.

While GAX has been in the works for several years, the first prototypes are just now being field-tested. The heat pump could hit the market within two years.—Charles Wardell

DEREGULATION

The Everything Utility

AS ELECTRIC UTILITY DEREGULATION spreads across the country—23 states have passed legislation so far—power prices have begun to drop [Home Newsfront, Nov.]. But another, unintended benefit for consumers is taking shape: Some power companies are now offering a lot more than electricity.

The reason, quite simply, is smart marketing. Consumers aren't clamoring to change power providers, so companies are trying to gain a competitive edge by offering a buffet of additional services—telephone, cable, and Internet services to name a few. The benefit to consumers? Bundled services are cheaper than they would be if offered separately.

But Connectiv of Wilmington, Delaware, is going a step further. Along with local, regional, and long-distance phone service, the company offers Internet access via a Digital Subscriber Line that's 60 times as fast as a conventional modem. Connectiv also offers a toll-free hot line for other problems in the home, such as a malfunctioning furnace or air conditioner, a leaky pipe, or a faulty water heater—regardless of the brand of the appliance. "We're trying to redefine ourselves as a provider of vital services," says CEO Howard Cosgrove.

And, oh yes, Connectiv also provides gas and electricity. It even offers "green" power—electricity that's generated from environmentally friendly sources like water, wind, and the sun.—Nada Mangialetti

WHY WRAP HOLIDAY GIFTS WHEN YOU CAN DOWNLOAD THEM?

Buy a Dell® Dimension® desktop PC and turn this holiday season into a digital wonderland. Include one of our digital cameras with your system purchase and take pictures to create holiday greeting cards that you can send or post on the web. And add some music to the holidays with digital Jukebox software, available on select Dimension desktops. With it you can download, record, organize and play the digital MP3 music that's out there on the web. Plus, Dell offers online digital tutorials—easy “how-ta’s” to help make your holiday full of special memories. Dell digital gifts. It's one more benefit of the Dell4me total ownership experience. A complete resource for products and services that make it easy for you to get the most out of technology.

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Pricing not discountable. Prices and specifications valid in U.S. only and subject to change without notice. For a complete copy of Guarantees or Limited Warranties, write Dell USA L.P., Attn: Warranties, One Dell Way, Round Rock, TX 78682. At-home or on-site service provided via service contract between customer and third party provider, and is not available in certain remote areas. Technician dispatched if necessary pursuant to phone-based troubleshooting with technical support personnel. Other conditions apply. For hard drives, GB means 1 billion bytes, total accessible capacity varies depending on operating environment. *17X Min. Download speeds limited to 50Kbps. Upload speeds are less (in the 30Kbps range) and vary by modem manufacturer. Speeds also vary depending on line conditions. Analog phone line end compatible server equipment required. *Includes 150 hours Internet access per month, with \$1.50 per hour charge for each hour (or fraction thereof) over 150 hours. Remote subscribers subject to additional charge of \$4.95 for each hour of Dellnet service. Excludes applicable taxes and local/long distance telephone access fees or charges. Additional \$1.00/hour surcharge for Dellnet service in HI and AK. *Online backup services are provided by a third party, and such services are provided subject to terms and conditions between such third party and the customer. Limited to 20MB online storage; additional storage space available at additional charge. Dell disclaims any responsibility for lost customer data. Intel, the Intel Inside logo and Pentium are registered trademarks and Celeron is a trademark of Intel Corporation. MS, Microsoft, IntelliMouse and Windows are registered trademarks of Microsoft Corporation. 3Com is a registered trademark of 3Com Corporation. © 1999 Dell Computer Corporation. All rights reserved.



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PHOTOVOLTAICS

Superthin Solar Cells

RESEARCHERS at the University of Florida are developing solar cells with a semiconductor layer thinner than a human hair and one-hundredth the thickness of silicon solar cells.

Traditional cells require relatively large amounts of semiconductor material, which drives up cost. The new thin-film cells could eventually prove far cheaper, for they would use only pennies' worth of material. That would be a boon to the burgeoning solar energy industry, and an environmental plus. Solar cells generate electricity without the pollution, and ease our reliance on fossil fuels. They can power a house or small business onsite, without being plugged in to electrical grids.

Key to the thin-film cells is a compound semiconductor called copper indium diselenide, which is deposited in an ultrathin layer—2 to 3 microns thick—on a material such as glass. Researchers elsewhere have demon-

strated that these cells can reach conversion efficiencies (sunlight to electricity) of 18 percent, rivaling the best silicon cells. But manufacturing them inexpensively is a challenge.

"They have a more complex structure and require more compli-

cated processing," says Tim Anderson, chairman of the UF chemical engineering department. "Our role is to better understand the processing and transfer the technology to industry." The cells could be available within 10 years.—Arthur Fisher

YEAR 2000

Are You Ready for Y2K?

FOR MOST OF US, the Year 2000 bug will come and go with nary a nuisance. Still, say experts, some areas of the country will experience isolated power, phone, and banking disruptions. Here are five things you can do this month to prepare—just in case.—W.G.P.

- 1 Have three days' worth of food, water, and cash on hand.
- 2 If you heat with natural gas or oil, get your tanks refilled.
- 3 Photocopy the previous year's financial statements.
- 4 Have a flashlight with fresh batteries handy.
- 5 Fill the family car with fuel.

Prototype



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Grab hold of the all-new ARROW ET100™ and experience the beauty of ergonomically designed comfort. Its non-slip cushioned grip and superb balance assures effortless work, even during long jobs.

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"EVERYTHING THAT CAN BE INVENTED has been invented," said Charles H. Duell, commissioner of the U.S. patent office, in 1899. Hope he wasn't a betting man. > It's tempting, as we say goodbye to the century that saw the arrival of everything from the airplane to the computer, to repeat those words. Or to wonder, even if to ourselves, if the world will ever again see so much innovation packed into a mere 100 years. > Bet on it. > As we move swiftly toward the 21st century, today's advances are laying the groundwork for some of the most important inventions and discoveries in human history. A full century after Duell's pronouncement, researchers this year proved that stem cells—the basic building blocks of human life—can be induced to grow into different tissues. The discovery could eventually enable doctors to grow human organs for transplant. The launch of the Chandra X-ray Observatory will provide important clues about the nature

**Popular
Science**

1999 BEST OF WHAT'S NEW

100 OF THE YEAR'S GREATEST ACHIEVEMENTS IN SCIENCE & TECHNOLOGY

of the universe, while a suburban Boston department store demonstrated electronic ink—the first step toward merging the look and feel of paper with the circuitry of computers. Meanwhile, a zero-emissions car moved one step closer to actual production, while a new outdoor vest promised to make the backcountry safer for hikers and skiers. > No, the rate of innovation won't slow in the next century. In fact, the pace promises to grow even faster. So as we celebrate the 100 greatest achievements of 1999, consider this—POPULAR SCIENCE's 12th annual "Best of What's New"—your preview of the next millennium. And after you've seen the editors' choices, tell us yours: Cast a vote on our Web site for your favorite award winner at www.popsci.com.

EDITED BY WILLIAM G. PHILLIPS

ASSISTANT PROJECT MANAGER SUZANNE KANTRA KIRSCHNER > PRINCIPAL PHOTOGRAPHY JOHN B. CARNETT



1999 BEST OF WHAT'S NEW >

RETRO COUPE The Audi TT brings us back to the small racers that zipped around European ovals in decades gone by. It's the most dramatic of the new retro designs—with copious polished aluminum accents inside and out—but don't be fooled by its good looks. The \$35,000 TT is powered by an advanced four-cylinder engine that feels much bigger. And its ride and handling are sure to put a smile on your face, particularly as you whisk through corners. www.audi.com



THIN AND RICH You won't have to sacrifice form for function with Ericsson's R380—the first cellphone-PDA combo that's the size of a regular phone. Flip down the keypad and you'll find a touchscreen running the length of the phone. This display enables you to browse the Web, keep a calendar and address book, or jot down a note. In personal-digital-assistant mode, the phone recognizes your handwriting. The jack-of-all-trades R380 also features a speakerphone and voice recorder. The phone will be available early next year; price will depend on service provider. www.ericsson.com

TWICE THE PICTURE Like a standard TV, the Sony 34-inch high-definition set is a direct-view unit—the first direct-view digital TV to hit the market (the others are projection TVs). As such, it offers a glimpse of what digital TV can be. The flat-screen TV features a technology called digital reality creation, which doubles the resolution of standard TV signals so they resemble digital TV images. And a multi-image driver lets you watch two different video sources at once. Price: \$8,999. www.sony.com



CLEAN-RUNNING SNOWMOBILE If you like snowmobiling but hate the environmental cost of high emissions, you'll be thrilled by the arrival of Redline's Revolution, the first snowmobile with an efficient, four-stroke engine. The engine produces 95 percent fewer hydrocarbons and delivers better fuel economy than a similarly sized two-stroke-powered snowmobile. Key to the advance: The engine is the size of a traditional two-stroke; the added weight of previous four-strokes offset efficiency gains because of increased fuel consumption. The 2001 Revolution will cost \$12,500. www.redlinesnowmobiles.com

GRAND AWARD /IATION & SPACE

HISTORIC FLIGHT

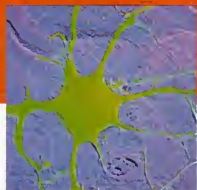
It was one of the last great frontiers in aviation: to circumnavigate the globe in a balloon. More than 20 teams had tried and failed. But this year, British pilot Brian Jones and Swiss psychiatrist Bertrand Piccard claimed the record ahead of several other competitors. On March 21, the duo and their balloon, the *Breitling Orbiter 3*, touched down in southeast Egypt after traveling nearly 30,000 miles. During their 20 days in the air after launching from the Swiss Alps, the team overcame broken equipment, survived dangerously low fuel levels, and braved endless expanses of desert and ocean before finally floating to their place in history. www.breitling-orbiter.ch



iMAC TO GO Apple brings its translucent touch to the world of mobile computing with the iBook (\$1,599), a laptop that's as well rounded inside as it is outside. Available in blueberry or tangerine, the iBook is powered by a 300MHz G3 processor and comes with both a 56Kbps modem and fast Ethernet port built in (a wireless AirPort networking card is an option). It also comes with 32MB of memory, a CD-ROM drive, and a lithium ion battery that runs up to 6 hours. www.apple.com



ELPH REDUX Perhaps the only thing harder than redefining the point-and-shoot camera is doing it again. But Canon managed just such a feat this year with the Elph2 (\$350), a pocket APS camera that is even smaller than the original Elph—yet finds room to include a 2X zoom lens, making it the world's smallest zoom camera. The Elph2 measures a mere 3.4 by 2.2 inches—smaller than a deck of cards—and is less than an inch thick. It weighs only 6 ounces. Yet with its autofocus system, zoom lens, and built-in flash, it takes great pictures. www.usa.canon.com



MENTAL METTLE Work frying your brain? Unfortunately, science won't back you on that—at least not anymore. Scientists had thought that human brain cells, unlike other biological cells, do not renew themselves as they die off. But researchers have discovered that brain cells do regenerate—and do so continuously throughout a person's life. The finding opens the possibility of treating disorders such as Parkinson's or Alzheimer's with cells taken from a patient's own brain. www.salk.edu

1999 BEST OF WHAT'S NEW >

SHOW ME THE MUMMIES Until they were found at the Bahareya Oasis, 230 miles southwest of Cairo, this cache of Egyptian mummies had remained undisturbed for 2,000 years. Since the discovery was announced earlier this year, 43 mummies have been found—and there may be thousands more. The mummies are unusual in that they exhibit both Egyptian and Roman attributes (such as Egyptian dress with Roman hairstyles).

Scholars expect the find to provide insights back to when this Egyptian provincial town was ruled by Rome.



SUPER ASSISTANT It's a cellphone. It's a pager. It's a GPS receiver. Actually, it's all of these—and more. Handspring's Visor (\$179) is a personal digital assistant that transforms itself into these devices at your whim. The pocket-size Visor, which runs on the popular Palm operating system, performs all the functions of 3Com's Palm III. The key difference: a slot in the back called the Springboard platform. Plug in a hardware module and the Visor instantly becomes an all-new device; no software installation is required.

Games and other software cartridges also plug in.

Several accessories, such as a keyboard (below), are also available. www.handspring.com



PICTURE PERFECT Looking for a convenient way to show off your digital pictures? No need to have prints made. Sony's Digital Picture Frame (\$499) is the first frame designed to display digital images—still or video. The 8.5- by 6.5- by 1.6-inch frame reads files stored on a Memory Stick, which you insert into it. Images can be presented as a slide show or manually selected. And you can hear video clips via a built-in speaker. The frame goes into sleep mode after 30 or 60 minutes. www.sony.com

BATTERY-POWERED MAID

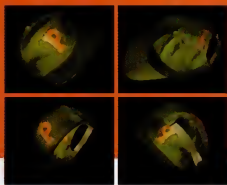
Plp the circular Eureka Robot Vac down in any room, walk away, and the vacuum does your dirty work for you. The 15-inch-diameter device, shown as a prototype this year, locates the perimeter of a room by following an exterior wall and then crosses the room in a random pattern. Radar embedded in the unit's bumper detects furniture or objects left on the floor. Run time for the Robot Vac (shown on its recharger) is about an hour. Recharging takes 2 hours. Eureka plans to sell the vacuum within a few years. www.eureka.com



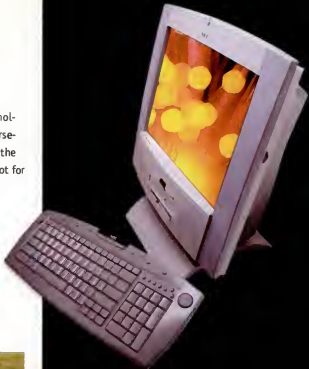
RACE CAR ENGINE FOR THE ROAD The Honda S2000, new for 2000, puts race car technology in the hands of the average driver. The sports car's 2.0-liter engine produces 240 horsepower at 8,700 rpm—the most powerful engine for its displacement on the road. Key to the advance: race-bred technology like forged engine parts and a variable valve system. It's not for everyone, but it will certainly please those who dare to drive it. www.honda.com



ALLURING CAMCORDER Clever and stylish has been an elusive mix for digital camcorders to date, but Canon's Elura (\$1,799) serves it up right. The compact and curvaceous Elura packs a video punch under the surface, with a 12X optical zoom lens and three shooting modes: digital video, digital photo, and progressive scan. The latter records high-resolution stills at 30 frames per second, enabling you to slow down fast-action sequences with remarkable clarity. www.usa.canon.com



SPINNING A 3-D WEB The next dimension in Web surfing will be depth, with lifelike 3-D images rather than flat 2-D pictures. MetaStream, a 3-D Web technology developed by MetaCreations and Intel, brings 3-D to the Web today. With a free browser plug-in, you can see and sometimes zoom, pan, and rotate 3-D images—inspecting a sweater inside and out, for example—on more than a dozen Web sites. Many more are in the works. MetaStream's magic is that it compresses and "streams" these 3-D objects rather than downloading them all at once, so it works even on slower Web connections. www.metocreations.com



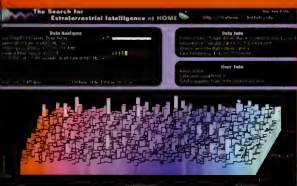
FORM AND FLEXIBILITY

NEC's new Z1 combines the appeal of a slim, lightweight all-in-one desktop—a computer in which the hardware is tucked neatly into what looks like a monitor—with the upgrade flexibility of a traditional desktop. The 20-pound super-slim Z1, starting at \$2,400, is the first all-in-one that lets you easily add hard disk capacity, memory, and even a new monitor. The Z1's 15-inch LCD panel slides up and off the main body so it can be replaced with an 18-inch panel (\$1,800). The Z1 also features a 450MHz Pentium III processor, an Ethernet port, built-in speakers, and a wireless keyboard. www.nec-z1.com

GRAND AWARD COMPUTERS & SOFTWARE

1999 BEST OF WHAT'S NEW >

MUSIC TO YOUR EARS With the Internet changing so rapidly, it might seem risky to invest in a digital MP3 music player. What if MP3, the favorite format now, goes the way of Beta? No need to worry with the RCA Lyra, the only MP3 player protected from obsolescence. Most MP3 player decoders are built in, but Lyra runs the decoders stored on external memory cards with the music, so it plays any format. Prices: \$199 (32MB), \$249 (64MB). www.rca.com



MILLION-MAN SEARCH FOR ET There's never been a screensaver like this before. More than a million people are now participating in the SETI@home project, an online search for extraterrestrial intelligence (SETI) launched in May. All it takes is a PC and an Internet connection: You download a chunk of data collected by a radio telescope, run a free screensaver that uses your computer's idle time to analyze the data, and then transmit back your results. Distributing the work makes it possible to analyze vast amounts of data without a supercomputer. setiathome.ssl.berkeley.edu



SNOWSLIDE SURVIVAL Take better equipment, add the allure of glistening white backcountry, and you've got a sharp increase in the number of skiers and hikers exposed to avalanches. Pondering this, Denver psychiatrist and skier Tom Crowley developed the idea for the AvaLung vest. Through a mouthpiece at the collar, a trapped skier can breathe the air in the snow around him and exhale through vents in the vest's back to avoid carbon dioxide buildup. The device does not eliminate the need for other safety measures, but it keeps a victim breathing for 70 minutes, greatly increasing the chances of survival. Cost: \$198. www.avalung.com

GRAND AWARD CARS

TECHNOLOGY ON THE CHEAP

Ford's Focus transcends the limitations of today's small cars with a roomy and efficient package, advanced technology like antilock brakes and yaw control, and a ride comparable to many luxury cars. A raised roof and upright seating create the roomy interior, which is topped off with an eye-catching exterior. A fuel-slingy, smooth-running drivetrain adds to the driving pleasure. Introduced in the U.S. this fall with prices starting at \$11,800, it's one of those rare designs that combine style and élan with low cost and economy, establishing a new baseline for what to expect in an affordable car. www.ford.com



FOR MORE INFORMATION, SEE RESOURCES OR VISIT WWW.POPSCI.COM

UNDER THE BIG TOP Opening January 1, 2000, the Millennium Dome in Greenwich, England, will be the largest dome in the world—with twice the ground area of its nearest competitor, the Georgia Dome. Made of a translucent weatherproof fabric that will be suspended from steel masts held in place by 43 miles of high-strength cables, the giant dome will accommodate 50,000 visitors at a time. It will be the setting for millennium celebrations and technology exhibits. www.dome2000.co.uk



THE DYNAMIC ATHLETE Wondering if pro football's Jerome "The Bus" Bettis really hits the line like a run-away motor coach? Soon you may know for sure. Earlier this year, a company called Trakus demonstrated a tracking system of the same name that could add a new dimension—and several new statistics—to all the major sports. Using tiny transmitters on players, and transceivers around the arena or stadium, Trakus measures player speed, acceleration, and force of impact. This season, the Boston Bruins will become the first professional sports team to test the system. www.trakus.com



PULL-APART APS Fully encapsulated in a sleek metallic oval body, Minolta's Vectis 2000 (\$249) hardly resembles a camera. But pull apart its protective case and the 2000 springs into action, with its 2X optical zoom lens extending and its built-in flash popping up like a raised eyebrow. Close it again, and it's ready for the hard knocks of a pocket, purse, or suitcase. And at 4 by 2 by 1 inches and 5 ounces, the camera won't take up much room either. www.minoltousa.com

TRIM MOUNTAINEER For mountain bikers, a power pack of design innovation has arrived on the wings of a raven. Cannondale's radical revamping of its Raven mountain bike achieves one of the lightest total packages (less than 25 pounds) around without stinting on stiffness and shock absorption. Most dramatic of the new ideas is the single-sided HeadShok Lefty suspension fork. And the internal magnesium spine with carbon-fiber skin tips the scale lightly while standing up to bumps. Price: \$2,200 to \$4,000. www.cannondale.com



EXTRA! WE ARE NOT ALONE Once we wondered, but now we know: At least one solar system beyond our own revolves around a sun-like star. Earlier this year, world-renowned planet finders led by Geoff Marcy of San Francisco State University and Paul Butler of the Anglo-Australian Observatory discovered a system of at least three planets around the star Upsilon Andromedae, which is 44 light-years away. The giant planets circle around their sun within the distance of our Mars' orbit—providing new clues about how solar systems may form. www.physics.sfsu.edu



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www.hpbakedbeans.com

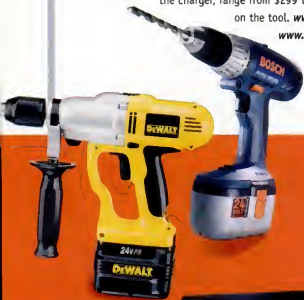


s an HP.

With the HP CD-Writer Plus and a powerful Intel® Pentium® III processor, the HP Pavilion 8565C is more appetizing than a perfectly-roasted smore.
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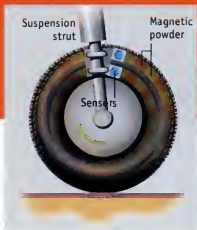
1999 BEST OF WHAT'S NEW >

MORE POWER TO YOU The Dewalt and Bosch 24-volt cordless tool lines put more power in your hands than ever before, increasing performance and run times. Previously, cordless tools topped out at 18 volts. Both lines include a circular saw, reciprocating saw, rotary hammer, and drill. The Dewalt tools also feature a corded adapter so you can swap out the battery if it runs low, while Bosch's 24-volt batteries can be recharged in a scant 15 minutes. Prices, including the charger, range from \$299 to \$599 depending on the tool. www.dewalt.com and www.boschtools.com



A TRADITIONAL VIEW OF HDTV Traditional televisions have a 4:3 aspect ratio—the picture's ratio of width to height. And now, thanks to RCA, so does high-definition TV. Conventional HDTVs come in only one flavor: the widescreen 16:9 aspect ratio. But when it's used with a converter box, RCA's MM36100HR set features the crystal clear 1,080-line resolution enjoyed with traditional dimensions by merely trimming the sides of the picture. The biggest benefit is cost. The RCA television lists for just \$2,599, substantially less than its widescreen competitors. www.rca.com

MODEL OF EFFICIENCY Looking for the most bang for your buck's worth of gas? You can't do any better than the new Honda Insight, which at 75 mpg is the most fuel-efficient car you can buy in the U.S. Insight achieves the breakthrough by employing a lightweight hybrid electric-gas drive system—it's the first hybrid-drive car available in America—and extensive use of aluminum. An electric assist improves acceleration, and an onboard battery absorbs energy from braking and uses it for recharging. Price: less than \$20,000. www.honda.com



STICK TO THE ROAD ON MAGNETS Traction control and antilock braking systems rely on sensors in different parts

of the car. But a new tire from Continental/Teves generates this safety information right where the rubber meets the road. The company's smart tire, unveiled this year, uses magnetic powder embedded in the tire sidewall to measure the strength of longitudinal and lateral forces. The result: The traction control and ABS systems get more accurate data more quickly. The smart tire is slated for introduction in 2002.

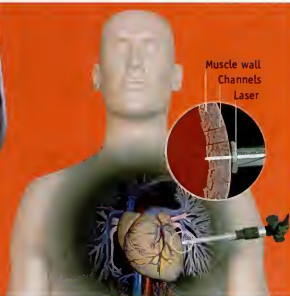
FLOATING LAUNCH PAD March 27 of this year marked the beginning of a new era in commercial space history. On that date, an international business partnership called Sea Launch successfully launched a demonstration satellite from a ship positioned within a few feet of the equator in the Pacific Ocean. Launching satellites from remote stretches of sea promises to reduce the costs of getting telecommunications hardware into orbit, in part because equatorial launch sites take advantage of Earth's spin to give rockets a boost. www.boeing.com/defense-spoce/space/sealaunch



FLEXIBLE THINKING IBM's ThinkPad 570 (\$2,699 and up) cleverly bridges the gap between a bulky laptop computer that has the power of a desktop and a lightweight portable that travels well. The key is the 570's innovative, and optional, UltraBase, which attaches to the bottom of the otherwise slim (1 inch thick) and light (4 pounds) laptop. The UltraBase can be configured with several options, including a CD-ROM, second hard disk, and Zip drive. But when it's time to travel, simply lift the laptop off the base and go. Either way, the 570 has plenty of power, with a 300-, 333-, or 366MHz Pentium II processor and either a 12- or 13.3-inch bright color screen. www.pc.ibm.com/us/thinkpad



GLOBETROTTER DIGITAL PHONE Motorola's new Timeport Triband mobile phone offers the best worldwide coverage short of an expensive satellite phone. The Triband does what its name implies: It works on any of the three GSM frequencies (900MHz, 1,800MHz, and 1,900MHz); GSM is the world's most popular digital cellular standard. The 3.8-ounce palm-size phone also synchronizes address and calendar information with your desktop PC, records voice notes, and supports voice dialing. The battery provides 120 minutes of talk time and 40 hours of standby time. Price depends on service provider. www.motorola.com



LIFESAVING LASER About 80,000 Americans are diagnosed each year with severe coronary artery disease that is untreatable with such conventional methods as angioplasty and bypass surgery. The clogged blood vessels cause victims to suffer fatigue and disabling chest pain. But the Heart Laser System, which was approved by the FDA late last year and came into widespread use this year, can alleviate their symptoms. Key to the system is a carbon dioxide laser that zaps 20 to 40 new channels into the heart muscle, probably replenishing blood supply (although this hasn't yet been proven). While the procedure is not a cure, it reduces the disease's symptoms and thereby boosts quality of life. www.plcmed.com

1999 BEST OF WHAT'S NEW >

HOW OLD IS THE UNIVERSE? In May, 27 astronomers announced that they had used the Hubble to precisely measure the distances to faraway galaxies such as NGC 4603 (below). With those measurements completed, the team was able to calculate the universe's rate of expansion—the Hubble constant—which in turn made it possible to calculate the age of the universe more accurately than ever: approximately 12 billion years. Previous estimates ranged from 10 billion to 20 billion years. www.hubbleconstant.com

EASY RIDER There have been mechanical auto-shifting bikes before, but Shimano's Auto D is the first electronic shifter—and it's by far the most advanced autoshift yet. No longer must you find low gear to climb a hill—the Auto D senses slowing wheel revolutions to upshift and downshift for you. The four-gear system also features an LCD that displays the gear you're in. There's a manual bypass too. The Auto D is available on the \$549 GT Autostream bike. www.shimano.com



IT'S A BLAST This June, the RS-68 rocket engine test-fired at the Air Force Research Lab at Edwards Air Force Base in Califor-

nia with spectacular results: It produced a thunderous 650,000 pounds of thrust—more than any single liquid oxygen-hydrogen engine in history. Made by the Rocketdyne division of Boeing, the RS-68 is the first large liquid-fueled rocket engine developed in the United States since the one aboard the space shuttle. And with fewer parts than the shuttle's engines, it promises greater reliability for launches on its intended expendable launch vehicle, the Delta IV, starting in 2001. www.boeing.com/space/rdyne



HIGH-TECH FUN AND GAMES Marking the beginning of a new era of video game systems, Sega's Dreamcast (\$200) has the raw computing power to blow away the current platforms—Playstation, Nintendo 64, and the company's own Saturn. Dreamcast's 200MHz Hitachi SH-4 processor, NEC PowerVR graphics chip set, and Yamaha Audio Engine work together to process data 10 to 15 times as fast as current systems. The benefits: smarter computer opponents, more realistic movements, and stunning detail. You can even see the bumps on the rawhide skin of the football. The system also features a built-in modem for Internet play. www.dreamcast.com



ROBOT PET

Aibo is a robotic version of man's best friend, complete with barking, begging, and tail wagging. But beneath the cute exterior lies a technological marvel from Sony. Consider what's involved for Aibo to chase a ball: The pup acquires and tracks the target, plots an intercept course, then makes a four-pawed approach. Maintaining balance and coordination on four legs has been one of the biggest challenges in robotics. Though today's Aibo is cute and lovable, Sony believes it will spawn genuinely useful offspring. In one scenario, the dog would fetch the phone for you when it rings. www.sony.com

FLAME PREVENTER More than 2,000 house fires start each year because someone has left a combustible liquid near a gas-fired water heater. Finally this year, from American Water Heater, comes an innovative solution. Flame Guard snuffs out flames before they can spread. Key to the system is a sealed combustion chamber. Flammable vapors can get into the chamber, but flames cannot get out. With the fire confined to the chamber, the water heater switches off the gas to extinguish the flames. The technology, available now, adds \$65 to \$80 to the cost of a water heater. www.americanwaterheater.com



THE F-DIGITAL Building on its F-Series tradition of professional SLR film cameras, Nikon's D1 (\$5,580) is a digital SLR for pros that has many of the advantages of the Nikon F5 or F100, including their 3D Matrix Metering and the ability to accept more than 80 F-mount lenses and accessories. As a digital camera, the 2.7-megapixel D1 is quick, with a boot-up time of less than 1 second. It also shoots 4.5 frames per second. www.nikonusa.com



SEE THE LIGHT-QUICKER Tail-lights haven't changed much over the years. But a new concept from Visteon Automotive Systems, demonstrated this year, will change the way automakers design cars. The system employs red lasers to illuminate thin, clear lenses, eliminating the tail light cavity and parabolic reflectors altogether. As a result, the lights would mold sleekly into the contours of a car body. And not only do lasers last longer, they illuminate 100 times as quickly as conventional bulbs. The technology should go into production by 2003. www.visteon.com

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1999 BEST OF WHAT'S NEW >

A ZOOM FOR ALL OCCASIONS The Tamron AF28-300mm is arguably the smallest, most versatile, and highest-quality zoom lens around. It owes its small stature to an internal mechanism that lets four lens barrels expand and contract effortlessly. Its range covers just about any shooting situation, so there's no need to carry multiple lenses around. Tamron also combines two glass manufacturing methods to create a lens that's remarkable for its clarity of image.

The lens sells for \$530.

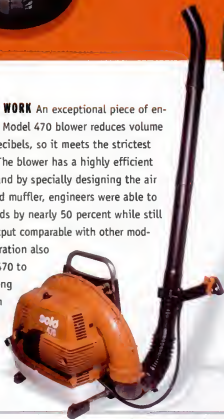
www.tomron.com



DECOMMISSIONING A DAM On July 1, a 17-mile stretch of Maine's Kennebec River flowed freely for the first time in 162 years. That day, a backhoe scooped away a temporary earthen coffer dam, allowing water to gush through a 60-foot cut in the Edwards Dam. It was the first time the Federal Energy Regulatory Commission had ordered an operating hydroelectric dam demolished because environmental costs—namely, destroying fish habitat—outweighed the economic benefits of cheap power. The dam's removal promises to help restore an important local fishery. www.ferc.fed.us and www.amrivers.org



SHHH, BLOWER AT WORK An exceptional piece of engineering, the Solo Model 470 blower reduces volume by a dramatic 13 decibels, so it meets the strictest noise regulations. The blower has a highly efficient two-cycle engine, and by specially designing the air intake, exhaust, and muffler, engineers were able to reduce engine speeds by nearly 50 percent while still achieving an air output comparable with other models. The slower operation also enables the Model 470 to run four times as long as other blowers on the same amount of gasoline. Price: \$399.



MONSTER TRUCK Building the Ford Excursion, new for 2000, was no small task—both literally and figuratively. To make the Excursion, the largest sport-utility vehicle on the road today, Ford had to civilize a heavy-duty commercial truck chassis. No easy feat, especially when you're dealing with such heavy-duty components as a twin I-beam front axle and a beefy frame. But you can't argue with the result: The Excursion combines a roomy, luxurious interior with hefty load-hauling capacity. A low-emission engine—along with a safety system designed to minimize the effects of crashes with smaller vehicles—round out the rather large package. Prices start at \$33,400. www.ford.com



FOR MORE INFORMATION, SEE RESOURCES OR VISIT WWW.POPSCI.COM

WINDOW INTO COSMIC VIOLENCE In July, NASA's Chandra X-ray Observatory launched into elliptical Earth orbit and quickly gave us a whole new view of the universe. The telescope is the third in NASA's series of Great Observatories (following the Compton Gamma Ray Observatory and Hubble Space Telescope). Astronomers need telescopes that "see" different wavelengths because details apparent in one type of light are not in another. As the world's most powerful telescope for X rays, Chandra will make images of the most high-energy events in the cosmos, such as supernovae and black holes. Its first image, of a supernova remnant, showed unprecedented detail—an indicator of great things to come. www.chandra.nso.gov



Transponder



Receiver



DON'T MISS THE BOAT It happens to even the most experienced scuba divers: You've been under for a while, exploring the nooks and crannies of the seascape, then decide to surface. So, like, anyone seen the boat? Maybe the water was murky—or maybe you just drifted farther away than you thought—but now you have protection from this dangerous situation. Uwatec's NeverLost consists of a transponder you hang on your boat and a receiver you take with you. When you're ready to surface, you check the receiver for the distance and direction to your boat. Price: \$350. www.jwa.com

Linux



WINDOWS OF OPPORTUNITY Is the world ready for an alternative to the Windows and Macintosh operating systems? Ready or not, Linux emerged this year as that alternative, complete with a graphical interface and a support system of millions of users on the Web. Just as important, Linux—which is rooted in Unix and has been nurtured along by many companies and individuals via the Web—is championing the "open source" movement of software that is owned and improved by many hands rather than one. www.linux.org

GRAND AWARD HOME TECHNOLOGY

MICROWAVE, MOVE OVER

Home-cooked fast food? An oxymoron no more. The General Electric Advantium oven, which went on sale in October, promises to be the biggest breakthrough in the kitchen in years. The Advantium uses microwaves and heat from three 1,500-watt halogen lights to cook two to three times as fast as a conventional oven. And since light does 90 percent of the cooking, the flavor of meats is locked in. All cook times are preprogrammed; for more precise cooking, however, a sensor measures incoming voltages and adjusts cook times accordingly. Price: \$1,300. www.geadvantium.com



1999 BEST OF WHAT'S NEW >

DISHWASHER INCOGNITO Imagine how surprised your snooping guests will be to discover that one of your kitchen cabinets is really a dishwasher. Fisher & Paykel's Dish-Drawer turns that very trick in high style. The appliance is also perfect for areas where you do heavy entertaining but don't want the eyesore of a traditional dishwasher, such as a family room bar. It comes with one or two sliding drawers; each can be operated separately. And because the unit is made from a polymer, it's substantially quieter than traditional dishwashers. Price: \$1,050 (single); \$1,650 (double). usa.fisherpaykel.com



TIME TRAVEL MADE EASY Flying between time zones can give your watch a workout. It can also confuse the daylight's out of you. But the Tissot Navigator makes it easy—and, yes, a little fun. The watch's outer dial features one city name for each time zone. Select the time zone you're in, press a button, and, voilà, the hands automatically move to the correct time. A perfect way to pass the time—literally—on a long flight. Price: \$495.

TWICE AS NICE Upping the ante for inkjet printers is nothing new to Hewlett-Packard, and its DeskJet 970 Professional Series printer deals some impressive numbers, including a maximum resolution of 2,400 by 1,200 dots per inch in photo mode and a color layering technology that places up to 29 ink drops per dot. But its most impressive number may be two—as in both sides of the page. The 970 (\$399) includes a duplexer for automatic two-sided printing, a first for inkjets. www.hp.com



DIGITAL DYNAMO You haven't been able to record high-quality digital TV signals on a standard VCR, because the resulting images are severely degraded. Now, Panasonic has solved that problem—perhaps even before you realized it was a problem—with the introduction of a digital VCR called the PV-HD1000. The \$1,000 VCR connects directly to your digital television. www.panasonic.com



RICE OF LIFE Genetically modified crops have long held promise as a way to feed the world's starving children. Until recently, however, they've done little more than stir up controversy. That changed this summer when scientists unveiled a strain of rice genetically modified to contain iron and vitamin A. Vitamin A deficiency afflicts 400 million people worldwide, leaving them vulnerable to infections and blindness. Iron deficiency afflicts up to 3.7 billion people, causing anemia and impaired mental function in children. The rice will be distributed free in developing nations.



TECH TOUR DE FORCE The new Mercedes S-Class features unparalleled luxury and technology. The suspension system, for example, dispenses with springs and uses compressed air to adjust stability. At high speed, the chassis lowers automatically to reduce drag. A grill-mounted radar (left) sounds an alarm and automatically brakes the vehicle if it detects another car or an obstacle ahead. During a collision, airbags deploy according to the severity of the impact. And a voice-activated GPS navigation system makes sure you get to your destination. Price: around \$70,000. www.usa.mercedes-benz.com



AND AWARD RECREATION

TICKET TO THE STARS

Backyard astronomy has never been easier or more appealing than with Meade's Autostar controller. Plug the remote-control-size device into the base of the ETX-90-EC Astro Telescope, and you've got a tour guide to the stars. Without any prior knowledge of astronomy, you can find more than 14,000 objects. The controller calculates the position of heavenly bodies based on time, date, and location, and the telescope swivels to lock on for you. To get started, you point the telescope north and fine-tune the location of the two brightest stars in the sky. The controller does the rest—and, like a good tour guide, it even provides interesting facts on the LED readout screen. Prices: \$149 (controller), \$595 (telescope). www.meade.com

In	Sn	Sb
49	50	51
Tl	Pb	Bi
81	82	83
114		

HEAVYWEIGHT DISCOVERY A team of scientists from Russia's Joint Institute for Nuclear Research and California's Lawrence Livermore National Laboratory reported in January that they had created an entirely new element, at that time the heaviest ever made, by bombarding plutonium with calcium atoms. Superheavy elements usually break down instantaneously, but the team kept their new element, 114, alive for a full 30 seconds. It not only filled in a blank on the periodic table but may suggest ways to create other long-lived heavy elements. www.jinr.dubna.su and www.llnl.gov

INTERNET CAMERA Putting graphics on the Web became easier this year with the introduction of Sharp's wallet-size Internet View-Cam—the first camera designed specifically for the Internet. The camera takes still shots and video, which can be reviewed on a built-in LCD. It uses state-of-the-art MPEG-4 compression technology to keep files small so downloads are fast. Images are stored on removable SmartMedia cards for transfer to a computer. Price: \$700. www.sharp-usa.com





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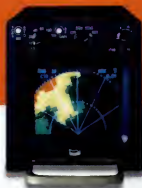
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1999 BEST OF WHAT'S NEW >

RADIO ON DEMAND Sick of your local DJs? Tired of getting the traffic report 2 minutes too late? Now you can listen to what you want when you want. Command Audio, introduced in several western cities this fall, enables you to choose the radio programs you want to hear—weather, news, traffic, or even an audio version of your favorite magazine (such as this one). The system continuously receives wireless transmissions of the latest programming to ensure up-to-date information. The \$200 portable device can also store up to 6 hours of programming. The monthly subscription costs about \$15. www.commandaudio.com



THE NEW ECONOMY The Lincoln LS, new for 2000, marks a new era for domestic cars, with performance and handling getting the same attention as comfort and ride. Taking cues from the best cars of Europe, where the sport sedan genre originated, the LS features handling as precise, and steering as responsive, as that of any car on the road today. Equipped with a standard V6 and optional V8 engines, the Lincoln LS is priced competitively as well—starting at \$31,700. www.ford.com



SAFER SKIES FOR ALL In a year when public attention focused on the safety of general aviation, AlliedSignal made a welcome announcement. The company's Enhanced Ground Proximity Warning System, which for years has alerted commercial pilots when they're flying dangerously close to mountains or the ground, will soon be available for private aviators. The system had been too expensive and bulky for small planes. Next year, in a paperback-size package, the system will go on sale for about \$10,000. www.alliedsignal.com

GRAND AWARDS AUDIO & VIDEO



EYE BY WIRE

Incorporating electronics and a video display into the temple of a pair of eyeglasses, Micro-Optical's Integrated Eyeglass Display eliminates the geeky look of bulky head-up gear. When cabled to any video output device, the 1-ounce display projects an image through the eyeglass lens. A tiny mirror inside the lens then reflects the image into the wearer's eye. The eyeglasses have many potential applications, but the first might be in medicine: As a surgeon operates, he or she could keep an eye on the patient's vital signs without turning away. www.microopticalcorp.com

Reception.



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antenna may be required. As of this writing, standards for Digital TV cable connectivity have not been finalized. Set-top decoder may not be capable of working with your cable system.

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DISCERNING DIGITAL Fussy about your pictures? Olympus' C-2500L (\$1,499) is a digital SLR with the highest resolution of any camera in the "prosumer"—professional quality cameras that consumers can buy—class. Its 2.5-megapixel CCD sensor yields crisp pictures at a resolution of 1,712 by 1,368 pixels. Resolution is refined further by Olympus' TruePic technology, which adjusts the picture inside the camera for a smoother, more film-like appearance. The C-2500L is also the first camera to have a dual CompactFlash/SmartMedia memory card slot, and features a 3X optical zoom lens, a low-light autofocus system, and a full range of SLR-style controls.

www.olympus.com



NEVER-STOP CORDLESS TOOLS When it comes to cordless tools, you take the good with the bad. Good: Battery-powered tools go anywhere. Bad: Battery-powered tools go dead. But with the Skil Tools' Dual-Source adapter, introduced this year, you get the flexibility of cordless with the security of a cord. When the battery goes dead, simply pull out the battery pack and plug in the corded adapter. The battery snaps into the adapter and recharges as you continue to use the tool. Later, pop the battery back in and you're cordless again. Dual-Source is available for Skil's line of drill-drivers, air guns, and flashlights. Prices range from \$79 to \$129, including the tool. www.skiltools.com



ALL TALK, NO ACTION Even solo drivers now have someone—more accurately, something—to talk to, thanks to Jaguar. The company's 2000 S-Type is the first car to feature voice control for the onboard radio, CD player, climate control system, and cellphone. Talking to the car may not be for everyone, but the technology lays the groundwork for safer interaction between the driver and a new generation of onboard electronics.

The system is an option on the elegant new S-Type sedan, which starts at \$42,500.

www.jaguar.com



6 FORCE The fastest Macintosh ever, the Power Mac G4 (\$1,599 to \$3,499) may be the fastest graphics PC, period. Built around a new PowerPC G4 chip, which Apple claims is the first microprocessor capable of executing a billion floating-point operations per second, the Power Mac G4 is a "gigaflop" machine designed to burn through the most demanding graphics applications—from the coolest 3-D games to complex Photoshop filters. The G4 also keeps the convenient swing-open side door of the Power Mac G3. One new option: Apple's widescreen Cinema Display (above left). www.apple.com

1999 BEST OF WHAT'S NEW >

BURIED TREASURE Three Incan mummies found in March by an American-Argentine-Peruvian team at the 22,000-foot summit of Mount Lullallaco in the Andes are among the best preserved human remains ever discovered. Two of the 500-year-old bodies even have intact internal organs and frozen blood. Scientists studying the finds hope to learn about the Incas' diet, religious practices, and genetic relationships to other ethnic groups. www.notionolgeographic.com and www.mountain.org/reinhord



JOHANN REINHARD

HARD AND FAST The 2000 Mitsubishi Eclipse brings newfound sleekness to the sport coupe genre. But the car is more than a bold design statement. A new, high-revving powerplant, a more rigid frame, and a refined suspension make it a pleasure to drive as well. With an excellent combination of comfort and handling—and a base price of \$17,700—the Eclipse is one of the best values on the road today. And it even comes with a useful rear seat. www.mitsubishimotors.com



BIG RIG This \$1.45 billion oil rig, the largest structure in the Gulf of Mexico, is positioned 130 miles southeast of New Orleans in almost 4,000 feet of water. That's about 800 feet deeper than any previous rig. Called Ursa, the rig has a platform hull that weighs about 28,600 tons, and a total displacement greater than that of a *Nimitz*-class aircraft carrier. It's large and strong enough to withstand hurricane-force winds and waves while tapping into an oil reservoir estimated at 400 million barrels. ms.shellus.com/sepco/ursa/ursa.htm

IMAGE BUILDER Lexar's new Jumpshot kit takes the wait out of downloading images from a digital camera to a computer, a notoriously tedious process. Simply use a Lexar CompactFlash card to take your shots, then slip the card into a cradle at one end of the Jumpshot cable. The cable plugs into the PC's USB port for transfer. It's that quick. The kit, which costs \$20, is available for both Macs and PCs. www.lexarmedia.com



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1999 BEST OF WHAT'S NEW >

A MOUSE WITH NO PAD Microsoft's new IntelliMouse Explorer offers some of the most accurate, well, mousing on the planet. The \$80 mouse uses a new optical tracking technology that takes 1,500 pictures per second; such resolution detects even the slightest hand movement and allows you to accurately place your cursor on the computer screen. The device also works well on just about any surface, eliminating the need for a mouse pad. Traditional mice can lose their accuracy as dirt, dust, and other substances find their way inside the rollerball cavity. www.microsoft.com/hardware



TAKING AIM AT ARTHRITIS Quality of life improved dramatically this year for millions of people suffering from arthritis, thanks to a new medication called Celebrex. Earlier anti-arthritis drugs not only blocked the inflammation-causing enzyme COX-2, but also the "good" enzyme COX-1, which helps regulate normal cell function in the stomach and blood. As the first arthritis drug to target only COX-2, Celebrex is less likely to cause ulcers. The drug, approved last December and co-promoted by G.D. Searle & Co. (the pharmaceutical arm of Monsanto) and Pfizer Inc., has generated more prescriptions in its first year than any other new drug, including Viagra. www.celebrex.com



PUTTING THE UTILITY BACK IN SUV Nissan's Xterra, new for 2000, is a back-to-basics sport-utility vehicle—that is, it's more at home in the mountains than at the mall. The SUV features a contemporary look, a frame-based chassis, and a smooth-running drivetrain. The result is an SUV that's retro in purpose but avant-garde in appearance. Keeping it simple, but functional, keeps the entry-level price around \$17,300. www.nissan.com



KEEPING GPS HANDY Getting lost is now harder than ever thanks to a Casio watch that comes with a GPS navigational feature—the first time GPS has been integrated into a device this small. The watch, perfect for hiking, mountain biking, and other outdoor sports, displays longitude and latitude or the direction and distance to a preset location. It weighs just 5.2 ounces. Price: between \$500 and \$600. www.casio.com



HOME THEATER MAGICIAN When it comes to home theater, the old mantra has always held true: Garbage in, garbage out. But not anymore. Bose's Videostage 5 decoder chip is the first technology that converts any audio source into 5.1 channels of surround sound—that is, three front and two side speakers plus a subwoofer. The decoder, in the Bose Lifestyle II, 40, and 50 series, gives stereo TV and even mono VHS tapes searing theater-like quality, increasing bass and reducing treble to augment dialogue and sound effects. Price: \$2,000 and up, depending on the system. www.bose.com

GRAND AWARD AUTOMOTIVE TECHNOLOGY

PRACTICAL FUEL CELL CAR

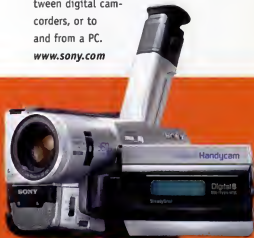
All the major automakers are studying fuel cells, but none has traveled quite as far as DaimlerChrysler. Fuel cells, which produce electricity through the chemical interaction of hydrogen and oxygen, offer enormous promise because they produce virtually zero emissions. DaimlerChrysler introduced the first Necar—a huge van—five years ago. This year, it unveiled the Necar 4, the first fuel cell vehicle that drives like a regular car. The bigger breakthrough, though, is that the company was able to shrink the drivetrain enough to fit it under a tiny A-Class subcompact sedan. www.daimlerchrysler.com



METAL IN THE MIDDLE Extra weight isn't usually a good thing. It is, however, if you're talking about Taylor Made's new FireSole golf clubs. The company placed weighted plugs—made of a combination of titanium, tungsten, and steel—in each club for maximum effectiveness. The quantity, size, composition, and placement of the plugs changes the center of gravity for each club, providing weight and power where it's needed most—an excellent combination of technology and performance. A set of eight irons is \$974 (steel) or \$1,169 (graphite); the driver is \$389 (graphite); fairway woods and rescue clubs are \$324 each (graphite). www.taylormadegolf.com



8MM GOES DIGITAL How do you bridge the analog video past with the digital video future? Sony does it with the first camcorders to combine the Hi8/8mm format with a digital video format called Digital8. Digital8 Handycam models (\$899 to \$1,399) can record home videos with as many as 500 lines of digital clarity using standard Hi8 metal tapes and can play back your current library of analog 8mm or Hi8 tapes. Also available is an iLink connector for moving videos between digital camcorders, or to and from a PC. www.sony.com



PURPLE POWER There may be many ways to pronounce Sony's Vaio label, but "wow" may be the first to hit your lips when you see its Vaio Slimtop LCD computer. True to the Slimtop name, it is a thin, elegant desktop PC with a stunning 1.4-inch LCD display that tilts to almost any position. The latest version of this violet-accented beauty, the PCV-L620 (\$2,499), adds a 13GB hard disk, DVD-ROM drive, and two iLink ports to an already potent system powered by a 500MHz Pentium III chip and 128MB of memory. www.sony.com

1999 BEST OF WHAT'S NEW >

SMALL CAMERA, BIG LENS Making digital cameras as small as point-and-shoot film cameras is challenging enough. Making one that small with a zoom lens has been impossible—until this year. Fuji's MX-1700 Zoom (\$599) digital camera is a small, sleek, upright model like the MX-700 and MX-2700 models that preceded it. But unlike those cameras, the MX-1700 has a 3X optical zoom lens, thanks to a breakthrough in Fuji's labs that led to the world's smallest, all-glass aspherical lens for a digital camera. And the MX-1700 has all of the essentials too, including a 1.5-megapixel sensor, a 2-inch color LCD, and an 8MB SmartMedia card. www.fujifilm.com



PINBALL WIZARDRY If the flippers, bumpers, and buzzers of pinball seem old hat compared with today's highly interactive video games, hang on. Earlier graftings of video onto the century-old standby were little more than superficial glitz. But *Revenge from Mars*, the first of a new generation of hybrids for Midway Video Games' revamped Pinball 2000 machine, lets you interact directly with video images that seamlessly blend into the play. It'll make your head spin with excitement. Price: \$4,100. www.midway.com



BEST OF BOTH WORLDS It's always been an either/or proposition. You either get a smooth ride or good high-speed handling. But Delphi Automotive Systems' new MagneRide suspension, shown in prototype this year, promises to change all that. MagneRide's shock absorber liquid, a combination of microscopic iron particles and conventional fluid, changes viscosity when exposed to a magnetic field from the shock absorber piston. The change is rapid—10 times as fast as a conventional shock. And it alters the suspension's damping with no mechanical valve changes. That allows a wide variation in shock action—from minimal damping to a virtually solid shock. The system should appear in production cars by 2003. www.delphi-auto.com



SATELLITE TV'S HARD CASE Echostar's Dish-Player satellite TV receiver is the first to come with a hard drive recorder similar to those found in computers. But in this instance, you get some very non-PC benefits, like being able to pause a live broadcast for as long as 30 minutes before resuming where you left off. You can also record up to 8 hours of high-quality video. The \$199 box even features WebTV for access to the Internet. www.echostar.com

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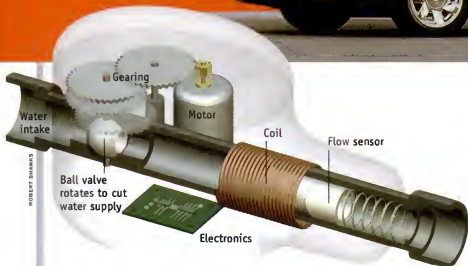
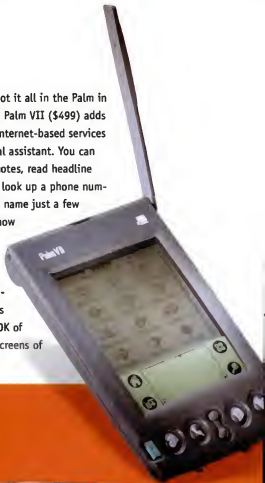


1999 BEST OF WHAT'S NEW >

FLYING BUS Sikorsky's S-92A Helibus, which flew for the first time this year, opens a new chapter in short-haul commuting. The helicopter carries 19 passengers in a cabin large enough for them to stand upright. It also gets them there in a hurry by cruising at 180 mph, a speed that would make other helicopters shake uncontrollably. Luggage is loaded through a ramp in the back. www.sikorsky.com



LUCKY 7 Now you've really got it all in the Palm in your hand. Palm Computing's Palm VII (\$499) adds e-mail and a host of useful Internet-based services to its popular personal digital assistant. You can book a flight, check stock quotes, read headline news, get driving directions, look up a phone number, or check the weather, to name just a few of the 100 options that are now available. To access these services, you raise the unit's antenna; a built-in wireless modem sends and receives the data. Service plans start at \$10 per month for 50K of data, or approximately 150 screens of information. www.palm.net



WATER WATCHER When you're away from home, there's comfort in knowing that circuit breakers are watching electrical loads and the security system is monitoring for break-ins. But there's never been a way to protect your home from leaky plumbing, the second-most costly insurance claim. Until this year. FloLogic measures how much water is flowing into the house through the cold water intake. If the rate exceeds a preset limit, the device automatically shuts off the water and sounds an alarm. The unit has two preset settings, home and away, for even more precise control. Price: \$200.

CUTTING-EDGE LUXURY Several features on Cadillac's 2000 DeVille place it squarely at the leading edge of technology. To wit: Adaptive seats automatically adjust to individual passengers; an optional infrared night-vision system allows the driver to see well beyond the high beams; and the GPS navigation system gives the driver audible directions. The full-size sedan also gets highly advanced electronic dynamic controls that smoothly balance the action of brake-activated yaw control and variable shock absorbers. As a result, the car is transformed from an unabashed highway cruiser to a car equally comfortable on winding roads. In addition, the restyled body houses a re-engineered chassis and a more efficient V8. Pricing starts at \$39,500. www.gm.com



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1999 BEST OF WHAT'S NEW >

LIGHT TRUCKS A breakthrough in the use of structural composites, this year Chevrolet demonstrated a pickup truck "box"—everything behind the cab—that is lightweight, corrosion-proof, and virtually indestructible. The composite, made from high-strength urethane molded with glass fiber, produces a bed that's stronger than steel. Flexible body panels are dentproof. To be introduced next fall, the pickup box is also a testbed for future composite structures.



MOURNING PAPER? NOT TO WORRY Think electronic media will make your morning newspaper obsolete? Not so fast. An electronic paper from E Ink, used for the first time this year for several J.C. Penney store signs, offers the look and the feel of the real thing without any need to recycle. E-ink displays—that is, the paper—contain microcapsules filled with electrically charged white particles and black dye sandwiched between two sheets of flexible plastic no thicker than a piece of paper. An electric charge applied to the sheet rearranges the colors to form different letters. The next step is to miniaturize the technology to re-



create the look of a newspaper or magazine—and, eventually, to add color.

www.eink.com



COUCH POTATO'S BEST FRIEND

There's never been a better time to be a couch potato. Not only does TiVo—a hard disk recorder for video introduced earlier this year—allow you to "pause" live

broadcasts, but it also decides what to watch. It does this by monitoring your viewing habits—the more you watch, the better it gets. Of course, you can also record specific programs. TiVo keeps a 30-minute running loop of everything you watch. So if you get a phone call during your favorite show, just hit the pause button. Hit the play button when you hang up to continue watching. Price: \$499 (14 hours of memory) or \$999 (30 hours), plus a \$10 monthly service fee. www.tivo.com



VIRTUAL AIRSPACE Military aviators will get a new look from the cockpit thanks to a head-up display shown for the first time this year. The Microvision virtual retina display uses a laser, monochrome-size optics, and tiny scanners to project an image directly onto the pilot's retina. The device allows the pilot to see the surrounding airspace while also accessing digital cues and images that appear to float in front of him. www.mvis.com

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1999 BEST OF WHAT'S NEW >

WIRELESS PERSONAL NETWORK Why must you be the liaison between, for example, your pager and cellphone? Wouldn't it be great if, say, your PDA could talk directly to your PC? Now, for the first time, it can. Bluetooth 1.0, a 2.4GHz wireless voice and data protocol, lets electronic devices share information at a swift 1 megabit per second when they're within 10 meters. Potential applications: When your pager goes off, your cellphone displays the number you're to call. Look for products from the Bluetooth founders next year: phones from Nokia and Ericsson, and PC applications from IBM, Intel, and Toshiba. www.bluetooth.com

INK JETTING Billed as the world's fastest color inkjet printer when it was introduced earlier this year, Epson's Stylus Color 900 (\$399) still reigns as the speed champ, capable of churning out documents as fast as 12 pages per minute (ppm) in black and 10 ppm in color—though refined photo-quality images take longer. Better still, the 900 uses the smallest ink droplets in the business (a microscopic 3 picoliters) to produce some of the best-looking pictures ever from a PC. www.epson.com



THE BIG LITTLE CAR A unique blend of economy and innovation, the Toyota Echo, new for 2000, offers a fresh look at low-cost transportation. The Echo sets standards for interior room in a small car, with upright seating and loads of headroom. That's not all. Crisp handling and perky performance set it apart from other entry-level cars. Trendsetting contemporary exterior design caps off the package. Prices start at \$9,995. www.toyota.com

GRAND AWARD PHOTOGRAPH

FILM ON DISC

Now you don't even need a digital camera or a scanner to get in on the electronic imaging fun. Picture CD, a photos-on-disc service developed by Kodak and Intel, enables you to simply check a box on the film envelope when you're getting your pictures processed to receive, along with the prints, a CD-ROM disc containing high-quality digital versions of each picture. You also get genuinely easy-to-use software on the disc for touching up your pictures and for e-mailing them to friends and family. The price is about \$10 per disc, in addition to regular film processing. www.kodak.com/go/picturecd



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AUTOMOTIVE SYSTEMS

1999 BEST OF WHAT'S NEW >

SMALL SHOOTER The Canon PowerShot S10 doesn't look any different from a small film camera, but that's the point. It's the world's smallest and lightest 2-megapixel digital camera. The 9.5-ounce S10 features a built-in zoom lens and easily fits in your pocket. Perhaps more impressive, it works with Type I and II flash memory cards and features a high-speed USB connector for easy downloading to a computer. www.uso.canon.com



GET FRESH How can you tell if prepackaged seafood is still fresh? A new way is with an indicator called a FreshTag. The quarter-size device uses technology developed by scientists at the FDA to detect gases produced as seafood decomposes. As the gases diffuse into the FreshTag, they cause a color change in its chemically coated wick. The tags will be expanded to poultry and pork. www.cx-en.com/freshtags.htm



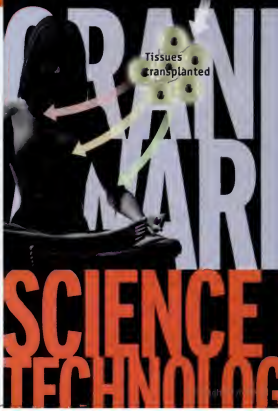
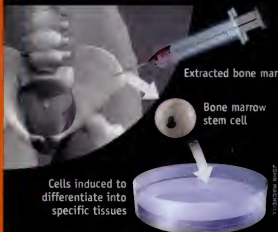
UTILITY WITH VERSATILITY The 2000 Chevrolet Tahoe may be the most versatile sport-utility vehicle on the road today. The SUV combines voluminous cargo capacity, stump-pulling towing ability, and full-size seating with a surprisingly refined suspension and a high-tech drivetrain. The SUV's re-engineered series of gas and diesel engines lowers emissions and improves power and fuel economy. Variable-ratio steering and adaptive ride control ensure precise and smooth driving—even as the vehicle handles a broad range of tasks ranging from recreation to hauling groceries. Prices start around \$30,000. www.chevrolet.com



CANDID COMPUTER Sony's PictureBook isn't just a 2.2-pound powerful micro-notebook computer. It's also the first to feature an integrated digital camera, which makes e-mailing digital shots a snap. The original PCG-C1X features a 266MHz Pentium processor and a 4.3GB hard drive. The next generation model will be based on the more powerful Japan-only PCG-C1XE (shown), which features a 266MHz Pentium II, swiveling 410,000-pixel camera, and 8.1GB hard drive. Price: \$2,000. www.sony.com

CURE FOR A BROKEN HEART?

In the beginning there was . . . the stem cell. Stem cells are the building blocks from which the entire human body grows. Scientists at Osiris Therapeutics discovered a new type of stem cell this year when they isolated the mesenchymal cell in bone marrow. What's more, they were able to induce these cells to grow into specific types of connective tissue, such as cartilage, bone, or fat cells. The feat could have profound implications: Stem cells could eventually be induced to grow everything from organs to blood. Doctors, for example, could grow tissue from stem cells and then transplant it into the same person to avoid rejection. Other applications: new muscles and tendons for sports injuries, and fat tissue for implants. www.osiristx.com



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covery of another solar system, p. 65, San Francisco State University, 1600 Holloway Ave., San Francisco CA 95064; Enhanced ground proximity warning system, p. 76, AlliedSignal, 15001 N.E. 36th St., Redmond WA 98073; Microvision Virtual Retina Display, p. 80, Microvision, 19910 Northcreek Pkwy., Bothell WA 98011; Rocketdyne RS-68 engine, p. 70, Rocketdyne Propulsion & Power, Boeing Co., Box 7922, M/S 4A49, Canoga Park CA 91309; Sea Launch, p. 69, Sea Launch, 2700 Nimitz Rd., Long Beach CA 90802; Sikorsky S-92A helicopter, p. 88, Sikorsky Aircraft Corp., 6900 Main St., Stratford CT 06615

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AVIATION & SPACE

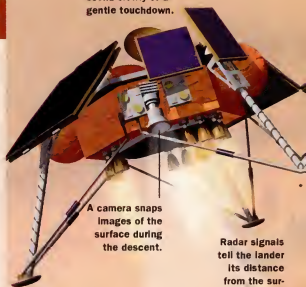
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1 A heat shield protects the lander as it speeds through the martian atmosphere at 16,000 mph. After friction slows down the spacecraft, it deploys a parachute.



2 A pair of Deep Space 2 microprobes jettisoned from the spacecraft penetrate the martian surface to analyze soil.

3 As it nears the surface, the lander jettisons its shield and chute, and fires its thrusters to descend slowly to a gentle touchdown.



A camera snaps images of the surface during the descent.

Radar signals tell the lander its distance from the surface as it approaches.

Mars INVASION

IF YOU COULD STAND ON MARS in its south polar region on December 3, you might think you were witnessing an interplanetary invasion: Out of the sky will come a trio of robotic emissaries from Earth. The three-legged Mars Polar Lander will make the first controlled touchdown on the Red Planet since the 1976 Viking landings. (The Mars Pathfinder lander "bounced down" in July 1997 using airbags.) Before it enters the martian atmosphere, Mars Polar Lander will release a pair of Deep Space 2 microprobes that will slam into the ground, burying instrumented capsules to study the planet's subsurface conditions.

The new mission, the latest in NASA's ongoing blitz of martian exploration, will try to solve the mystery of how a planet that once had flowing rivers—and perhaps life—became a cold desert world. Scientists have selected a landing spot near Mars' south pole where orbiting spacecraft have photographed what appear to be thick layers of dust and ice.

This so-called layered terrain may be a kind of history book spanning hundreds or even thousands of millennia of climate history. Up to now,

though, this terrain has not been well understood. "We really don't know what we'll see at the surface," says UCLA's David Paige, principal investigator for several of the scientific experiments aboard the lander.

In one key experiment, the lander's robotic arm will scoop up soil samples that will be heated in a tiny oven; sensors will measure any water vapor and carbon dioxide that are released. Scientists should be able to learn how much ice is in the soil, and whether it contains carbonate minerals that could have formed in an ancient martian lake.

Meanwhile, the most sophisticated meteorology package ever sent to Mars will be busy studying the atmosphere. Sensors will gather detailed information on wind speeds and temperatures at the surface, as well as the first onsite measurements of atmospheric water vapor. Scientists are especially eager to understand how water migrates between the atmosphere and surface. They also hope to determine the wind speeds necessary to loft surface dust, a key to the creation of martian dust storms.

The lander is well equipped to photograph the surface. A twin of the camera used on the Pathfinder mission will produce high-resolution color panoramas. The lander also has a descent imager to record views of the surface shortly before touchdown. And a close-up camera on the robotic arm will reveal surface details as small as 20 microns across.

During the lander's 90 days of operations, the arm will dig a trench 20 inches deep, then photograph the trench walls, where scientists hope to measure individual dust layers. That could reveal how quickly the layers formed—a first step in understanding Mars' changing climate. ▶

Two microprobes and a lander will descend to the Red Planet this month, seeking to solve its deepest mysteries.

By Andrew Chaikin

Take your family on a trip through the solar system.

Open the window and explore entire worlds previously hidden. Land, sea, or sky. The new 60mm refractor scope, based on huge observatory scopes, magnifies your view a whopping 675 times. Count the rings of Saturn. Explore distant constellations. The craters of the moon. Razor-sharp optics are fully coated, nullifying glare to give you headline definition. View a hawk a mile away. A boat on the horizon becomes a vivid close-up. Equatorial mount, with vertical and horizontal fine tuning, lets you track the movement of all heavenly bodies. Crosshair finder-scope rides on top, scans at low power to locate views quickly. Included lenses double and triple your seeing power. Included rugged aluminum tripod adjusts from 3' to 6', so you can enjoy the scope outside or resting in your easy chair! Either way, the universe is now yours. At a very down to earth price.

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Missing in Action

THE MARS CLIMATE ORBITER was supposed to relay data from the lander to Earth, and later conduct a mapping mission as the first interplanetary weather satellite. But the orbiter approached Mars at a lower altitude than planned, and probably burned up in the atmosphere. The lander can communicate directly with Earth, but data transmission is slower without a relay.



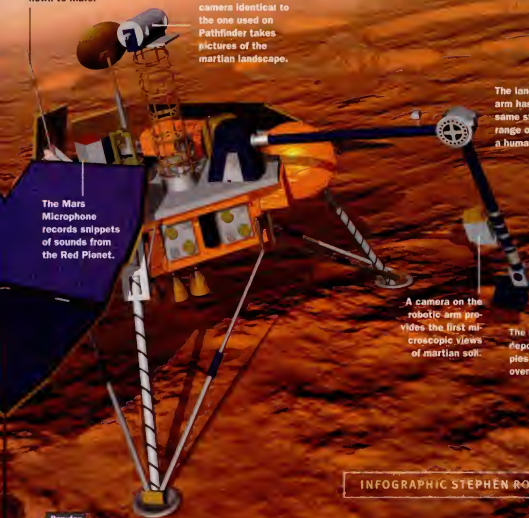
- ➊ After the landing, solar power panels and other instruments fold out on hinges and masts.

The meteorology station is the most advanced ever flown to Mars.

A stereoscopic camera identical to the one used on Pathfinder takes pictures of the martian landscape.



Mars Polar Lander will explore layered deposits of dust and ice (outlined in white) at the south pole. The terrain has few of the large craters and peaks seen at the Pathfinder landing site.



The Mars Microphone records snippets of sounds from the Red Planet.

A camera on the robotic arm provides the first microscopic views of martian soil.

The lander's robotic arm has about the same strength and range of motion as a human arm.

The robotic scoop deposits soil samples into a tiny oven for analysis.

What We Expect to Get from the Mars Polar Lander



Stereoscopic, panoramic images of the martian south pole



Data on clouds and water vapor in the atmosphere



Information on soil composition from microprobes and lander



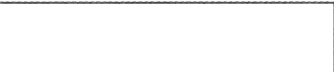
Detailed measurements of water concentrations



The sounds of Mars

INFOGRAPHIC STEPHEN ROUNTREE

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The future is here. And today's students are it. That's why we're combining the hard work of community leaders with our resources, to bring new ideas to the classroom. Like collaborating with teachers to get kids excited about math and science. And introducing innovative ways to utilize technology in the classroom so they can take their learning even further. To learn more about how we're doing in school, visit us at

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intel.



Wired classrooms network students while they learn Internet skills for the jobs of tomorrow.

STUDENTS in Oklahoma City's ethnically and economically diverse Western Heights school district are much like their counterparts in many of today's public schools. They struggle to meet basic reading, math, and science requirements. Their test scores are below the state average. Only six in

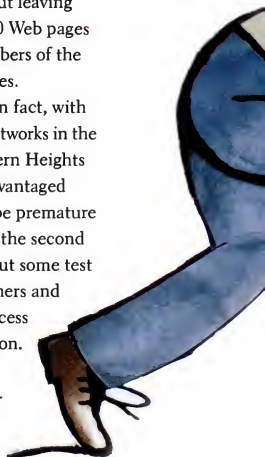
10 graduate, and less than half go on to college. They also take virtual field trips without leaving the classroom, scour more than 80,000 Web pages a day, and occasionally interview members of the British Parliament via videoconferences.

OK, so they're not exactly typical. In fact, with one of the most advanced computer networks in the nation for a K-12 school system, Western Heights is likely one of most advantaged/disadvantaged districts in the United States. It may be premature to gauge the results—the district is in the second year of a five-year technology plan—but some test scores have crept up slightly and teachers and students are hailing their newfound access to information and easy communication.

This much is clear, however: Their cutting-edge network (secured the old-fashioned way, with two-thirds of the money raised through school bonds) also puts them at the leading edge of an educational quandary. When schools underperform, do you heed the back-to-basics call and focus



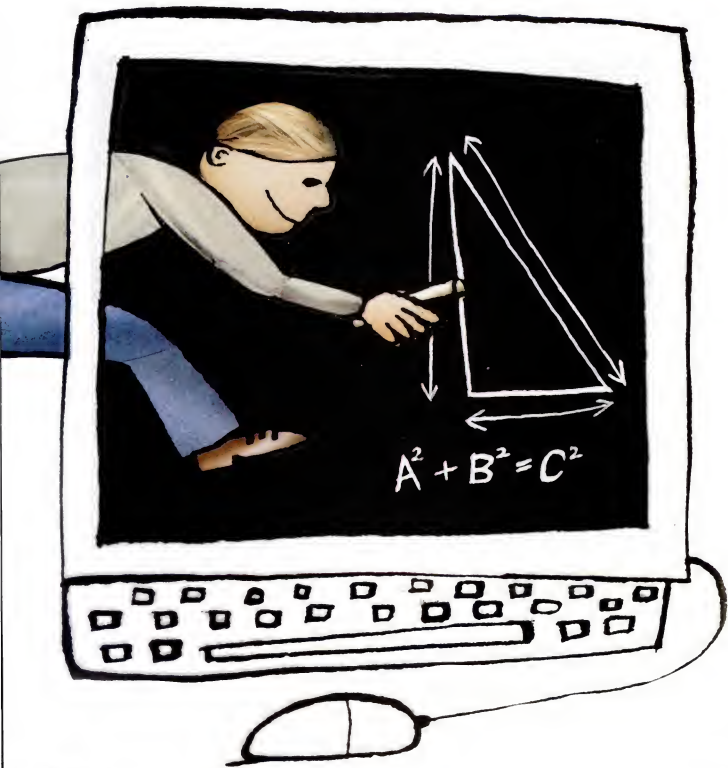
Technology coordinator Daryl McDaniel at the Western Heights school district's network control center in Oklahoma City.



By Chris O'Malley

ILLUSTRATIONS SCOTT MENCHIN
PHOTOGRAPHY JOHN B. CARNETT

SURFING @ SCHOOL





more intently on achievement in standardized tests? Or do you take a broader approach, re-examining what the information age "basics" should be and applying the same tools and techniques that have the economy booming?

Western Heights did not abandon the core subjects, and there are still plenty of well-thumbed textbooks in use. But watching a growing disparity between how their schools teach and how the rest of their community operates, the school board decided to take a dramatic step: Create a network of seven schools and 3,000-plus students that would not only put modern PCs in classrooms, but link them all with one another and the outside world through high-speed video, voice, and data connections. Then use it to rethink how teachers teach and students learn. Treat the ability to find and analyze information on the Internet as a basic skill. Make student collaboration a must. Allow middle-school children to take advanced courses taught in the high school or other schools through real time, interactive video hookups. Reach out to homebound students with computer loans and remote classroom links, and enable all children to keep learning after regular school hours with Web activities. Give teachers the training and the flexibility to find new ways to impart both new lessons and old.

"There are two ways to think about technology in education," says Joe Kitchens, superintendent of the Western

Heights school district and a leading proponent of its high-tech makeover. "It can help you teach the subjects you already teach, which is important. But it can also help you teach things you would not be able to teach otherwise. And the ability to use technology itself has become such an integral life skill that we have to teach that as well. We can talk about test scores all we want . . . but if our [K-12] students can't use technology, they will be denied in higher education and the workplace."

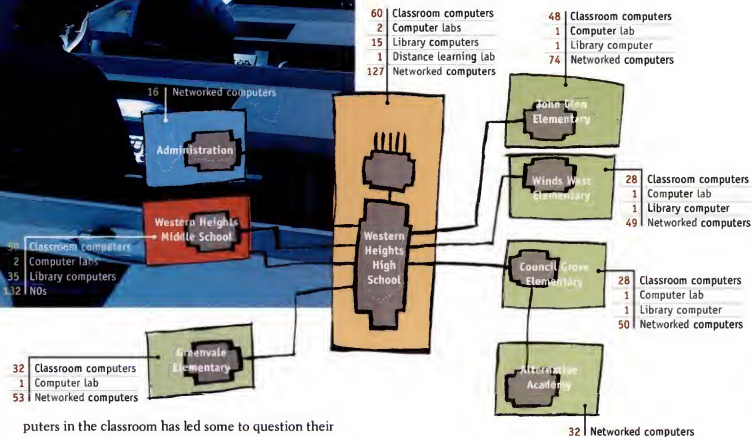
Many K-12 schools seem to be coming to the same conclusion. Elementary and secondary schools will spend another \$2 billion or so on classroom PCs this school year, according to Quality Education Data, but perhaps twice that much on the networking hardware and telecommunication services needed to connect them—partly due to the availability of government grants. Far from being islands of automated teaching, today's classroom PCs are more likely to be portals on a powerful local or state school network, as well as the Internet at large.

While connecting computers and making the vast resources of the Internet available to students and teachers clearly opens new avenues for leveraging those investments, there is no guarantee that kids will be more engaged and perform better. Indeed, the painfully slow learning curve of the 1980s and 1990s in discovering how to best "fit" com-



Learning from a Distance

AT THE Western Heights school district in southwest Oklahoma City (left), Debbie Beeman (standing) teaches algebra to ninth- and tenth-grade high-school students while eighth-grade students located at the separate middle-school building "attend" the class remotely. Below shows how all of the district's schools are linked for remote learning. The district boasts 5.6 students per computer, compared with a national average of 13.0.



puters in the classroom has led some to question their effectiveness. Even now, many educators insist that "integrating" computers into existing curricula and lesson plans is the Holy Grail of classroom technology use. But the early reports from the front lines of schooling in the Internet era seem to suggest that imagination—a willingness to expand the curriculum and try nontraditional teaching tools—may be more important than integration in making the most of new technology.

In the Western Heights district, that imaginative spirit takes many forms. In math teacher Debbie Beeman's case, it means not only teaching to the students in her room, but to the middle-school and homebound students who sit in on her lessons via a live video feed carried over the computer network. It means letting her students surf the Web for data on businesses and financial markets to discover how the numbers are juggled in the real world, or using a space shuttle launch countdown as a study in negative numbers. It means treating the ability to find and use information as a critical skill, not just a means to an end, says Beeman.

A connected community of schools can also increase the sheer variety of courses that students are exposed to, and effectively create a pool of educational talent that all can draw upon. In Wisconsin's Fox River Valley area, a cooperative distance learning network linking more than 30 high schools gives 70,000 students educational choices they otherwise wouldn't have. Thanks to a video-capable network spanning seven counties, students in Waupaca can now study Japanese, even though the course is conducted several miles away at a school in Menasha. Students can also take courses in criminal justice, veterinary science, advanced psychology, starting a small business, and dozens of other subjects. "Most of these courses simply wouldn't be available without the network," says Lee Blahnik, director of technology for the Oshkosh district.

As in Western Heights, the Fox Valley network, which employs 230 miles of fiber-optic cable as its information



BRAND GAMMA LIAISON



From home to Harvard: Right, Rio Gabriel Brennan, now 18, shares his subjects and his mother, Josephine Coatsworth, arranged the study groups.

HOME, SCHOOL HOME

AT AGE 10, when most kids seek independence, Rio Gabriel Bennin decided he wanted just the opposite: He asked his parents to school him at home. "He wanted the freedom and opportunity that came with it," says Rio's mother, Josephine Coatsworth. It took some convincing on Rio's part, but by the time he was 12, his parents conceded to his request. This year, as a high-school senior, he took home a perfect 1,600 SAT score and fifth place in the prestigious Intel Science Talent Search. With his project, "N-Dimensional Equalizers and Pythagorean Quadrilaterals," he devised a method for dividing a geometrical figure into two equal parts.

Rio has lots of company: Home-schooled kids tripled in number between 1990 and 1995—and today total about 1 million, estimates Patricia Lines of the U.S. Department of Education. Fueling the trend are parents dissatisfied with curricula or concerned about their children's safety in the light of recent shooting incidents.

While prepackaged curricula and books are available, parents needn't do all the home schooling. Several organizations offer support for combining kitchen table lessons with classes at other parents' houses, apprenticeships, and courses in a formal school setting.

Likewise, Rio chose his subjects and Coatsworth then organized discussion groups, writing classes, and tutorials. Other than a stint at high school for ninth and tenth grades, Rio was home schooled from seventh grade on.

While Rio admits he missed some social aspects of high school, he has no regrets: "I got to learn what I wanted at my leisure." Rio, now 18, plans to attend Harvard next fall. —Gunjan Sinha

highway, is capable of quickly routing two-way digital video (using MPEG-2 technology) to multiple locations at TV-like frame rates, for a fluid real time picture. Each school on the network can broadcast distance-learning courses, which originate in classrooms equipped with three large monitors in the rear of the room, each cabled to the network, so the teacher can see and hear the remote classrooms to which he or she is broadcasting. Video cameras enable the students at the remote sites to see and hear the teacher as well as the other students. Remote students can raise their hands and ask or answer questions, just as they would if they were in the same room as the teacher. Students also have access to the Internet at speeds up to 10 megabits per second (Mbps), or roughly 300 times faster than a conventional 33.6 kilobits per second (Kbps) modem. Since many of the participants are from smaller, rural schools with few resources for elective courses, the link to other schools can be a vital tool for keeping pace.

Bringing together schools in different parts of the state or country can have other ramifications too. A network of small school districts in Washington state called the Washington Virtual Classroom is pairing off the "haves" and "have-nots" to bring everyone more quickly up to speed on the potential of online learning. In the process, they are creating some original courseware that's relevant to the environment in which they live. There have been courses on measuring water quality, salmon ecology, and state history, for example. Such projects can be both more engaging to students, and more challenging to teachers—in part because today's video-and-computer kids can become even less content to sit through traditional instruction, says John Jones, superintendent of the Quillayute Valley school district on northwestern Washington's Olympic Peninsula. "Teachers can either be a sage on the stage, or a guide on the side," explains Jones, who was instrumental in creating the network. "But kids today have way too much stimulation for teachers to sit back and present material the way we might have years ago."

Not all of these networks are regional. The Washington Virtual Classroom was inspired by the Virtual High School project, a cooperative online learning network sponsored by 88 high schools in more than two dozen states. Funded by a grant from the U.S. Department of Education, the project requires teachers to first complete a graduate-level "NetCourse" to learn how to develop Internet-based courses for students. In exchange for sponsoring at least one online course, schools can enroll students in Virtual High School courses being offered by other schools. Some of the intriguing choices: Eastern and Western Thought—A Comparison; The Bioethics Symposium; Business in the 21st Century; A United Nations Simulation; and Earth 2525: A Time Traveler's Guide to Planet Earth.

Increasingly, technology is itself becoming an educational focal point, not merely a delivery system—a twist with no small amount of irony, since the notion of study-



THE DOLLAR DIVIDE

THE HOMOGENIZING influence of TV and other mass media can easily leave the impression that we are a nation of more or less equals, and that the K-12 schools in rural and inner city America are probably pretty much like the ones in the suburbs. But the reality is that urban and rural schools, as a group, tend to have far fewer dollars to spend on computers and other high-tech goods and services than schools in more well-to-do suburban areas.

Still, there are reasons to be optimistic. The Telecommunications Act of 1996 expanded the purpose of the Universal Service Fund—essentially a tax on the telephone companies originally imposed to bring phone service to low-income households and hard-to-reach areas. It now includes bringing high-speed Internet access, and the necessary computers and internal networks to share it, into schools and libraries. This so-called education rate, or e-rate, provides for discounts as high as 90 percent on such telecom services, or a \$2.25 billion sub-

sidy for the 1999-2000 school year, which makes Internet services affordable to many more school districts.

Even so, outfitting an entire district can be a costly and complicated project that requires other funding sources. In Oklahoma City's Western Heights school district, for example, 67 percent of the \$8.4 million needed for a seven-school network came from bonds approved by the community, while 19 percent came from the e-rate program. Other grants and donations made up the rest. Such bonds are increasingly popular, since they benefit education without requiring near-term tax raises.—C.O.

Who's Connected?

THE GOAL of the Clinton Administration has been to have every school connected to the Internet by the year 2000. How much progress has been made? While the number of schools connected continues to increase, the numbers are still low and significant differences between wealthy and poor school districts remain. The government, however, expects the rate to grow exponentially as more schools take advantage of the education rate (e-rate) program implemented in 1998 whereby schools can apply for reduced-rate telecommunications links.—G.S.

PERCENT OF public schools with instructional rooms to teach children about computers and the Internet in 1994 and 1998.

BY REGION	1994		1998	BY MINORITY ENROLLMENT	1994		1998	BY STUDENTS ELIGIBLE FOR FREE/REDUCED LUNCH	1994		1998
Northeast	3	39		Less than 6%	6	57		Less than 11%	4	62	
Southeast	2	51		6 to 20%	4	59		11 to 30%	4	53	
Central	3	61		21 to 49%	4	52		31 to 70%	3	52	
West	5	51		50% or more	3	37		71% or more	2	39	

SOURCE: U.S. DEPT. OF EDUCATION, NATIONAL CENTER FOR EDUCATION STATISTICS

ing computers has been largely discredited in recent years as PCs moved out of the proverbial lab down the hall and into regular classrooms. But that was before the Internet and its slew of new dot-com companies began radically transforming the U.S. economy, and in the process altering our notions of the skill set that many students will need to compete for college admissions and jobs. And it's all happened so quickly that many K-12 schools find themselves struggling to keep up with their students, who often have computers and Web access at home. Traditional coursework alone may not be enough to hold their attention, much less prepare them for what lies ahead.

Some schools are remaking themselves in the image of the high-tech entities around them. The Clark Magnet School in Glendale, California, not far from NASA's Jet Propulsion Laboratory, lures students to a refurbished high school by offering the latest in computer science instruction and related technologies. With an eye toward providing the high-tech skills students will need to land a job or go on to a technical trade school or college, the Clark campus has five highly wired and networked buildings. But it also has something even more important: students who want to be there, and an atmosphere of real world competition as they work on technology projects

that are central to the curriculum. "I like to joke that we don't necessarily have the smartest kids in the district, but they think they are," says Principal Douglas Dall. "There is peer pressure here to perform, and a real sense of accomplishment when they do."

Similarly, at Oak Grove High School in San Jose, near the heart of Silicon Valley, students can opt for an engineering "pathway" of high-level math and science courses that apply those skills to real-world applications. Courses include computer-aided drafting, robotics, semiconductor manufacturing, aerodynamics, and civil engineering, among others. Students in the computer drafting course design toys and the production plans to actually build them, which volunteers then create and distribute to needy children.

So are a new generation of high-tech schools and teachers the answer to underachieving students and poorly prepared job seekers? For some schools and some students perhaps. But most experts are quick to point out that even high-tech kids and classrooms need to build on the basics, not abandon them, if they expect to succeed. The real promise of networked schools and the Internet may be that they can fire the imaginations of educators and students alike, making the essentials and the extras come to life in ways that textbooks and chalkboards alone cannot. ▶

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AVAILABILITY

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MEDIA TYPE

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PROCESSOR TYPE

200MHz 128-bit SH-4

MODEM

56.6Kbps built-in

TITLES SHOWN

Shenmue (right),

NFL 2K

(lower left)

SEGA DREAMCAST

SONY PLAYSTATION 2

PRICE

Not available

AVAILABILITY

March 2000 (Japan),
fall 2000 (U.S.)

MEDIA TYPE

DVD disc, CD disc

PROCESSOR TYPE

300MHz 128-bit

"Emotion Engine"

MODEM

None

TITLES SHOWN

Tekken TAG

Tournament

(right),

Dark Cloud

(lower right)

By Suzanne Kantra Kirschner

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ILLUSTRATION RODD MARCUS

"YOUNG DROPS BACK into the pocket and rifles a long pass downfield. Rice catches it . . . heads for the end zone... and scores! What a play!" Another Sunday afternoon, another football game.

Or is it? Peeking into the living room, I see my husband and brother-in-law leaning forward, watching TV with rapt expressions on their faces. Not much of a sur-

prise there. But on second glance I realize that they're not clutching mugs of beer, but video game controllers, and the uniformed men running around onscreen aren't real players. The deceptively lifelike figures are part of NFL 2K, a game for Sega's new Dreamcast video game system. "Come check this out," invites my husband, who's watch-

ing an instant replay of the touch-down. He pauses the play and zooms in on the football so tightly I can see the bumps on its rawhide surface. Now that's detail.

It seems that gloriously rich details are the highlight of the first games developed for next-generation video game systems—Sega Dreamcast and Sony Playstation 2 (Nintendo hasn't shown any games for its code name Dolphin system, which will be available worldwide next fall). But when you get beyond the razzle-dazzle of seeing the players' rippling muscles

and the pinholes in their jerseys, you'll realize that the Dreamcast and Playstation 2 don't just make the games look better, they also make them a lot smarter.

NFL 2K was the smartest of the initial Dreamcast games we tested and perhaps most indicative of the caliber of titles that are to come. (The other games that we tested do trade mostly on their good looks.) The game was particularly canny when it came to defensive plays. My husband found that if he ran the same offensive plays a few times in a row, the

game's artificial intelligence would notice—just like a human would. The computer reacted like a good defensive coach, and it quickly became impossible to run the play successfully again. Since my husband had few options in his playbook at the time, he was soundly defeated.

The smarts that enabled the video game to learn from his behavior are a function of raw computing power. And computers have come a long way in the three years since Nintendo 64 (N64) was launched in the United States, and even more in the four years since Sega Saturn and Sony Playstation came out in the United States. So it's not surprising that the next-generation systems blow away the current models. Take Playstation versus Playstation 2 (available in Japan in March 2000, and here in the fall of 2000). Playstation has a 32-bit RISC processor running at 33MHz. Playstation 2 has a 128-bit "Emotion Engine" processor running at 300MHz.

A similar story plays out for Dreamcast, which sports a Hitachi 200MHz 128-bit SH-4 processor, versus Saturn, which has a 24MHz 32-bit processor. Likewise, Nintendo's N64 machine, which houses a 100MHz 64-bit processor, will be superseded by Dolphin, which features an IBM 400MHz Gekko processor.

A lot of speed won't do you much good if you don't have much to process. Dreamcast game discs can hold 1 gigabyte of material (about twice as much as the CDs used today), enabling game designers to create larger, more interactive, and realistic environments. Dolphin will use a proprietary DVD technology, which should deliver more than 4GB of storage. And Playstation 2 uses both regular DVD discs, which hold 4.7GB, and compact discs. The CD playback (thanks to the addition of some internal circuitry) enables you to play all

The top-loading Dreamcast system supports four controllers right out of the box—two more than Playstation 2 has.



Dreamcast's memory cards, called Visual Memory Units or VMUs, do more than store games, special plays, and unique characters. They also serve as stand-alone game machines.

NBA 2K (\$50) makes you feel like you're in the game with stunning graphics and intelligent plays.



MORE THAN 30 Dreamcast titles (\$40 to \$50) will be available for the holidays. Here's a sampling:

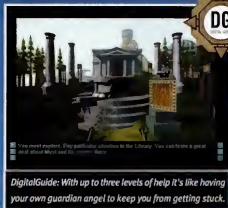
- Ready 2 Rumble (boxing)
- TNT Motorsports HardCore Heat (off-road racing)
- Airforce Delta (air combat)
- Suzuki Alstare Extreme Racing (motorcycle racing)
- Shenmue (action-adventure)
- NFL Blitz 2000 (football)
- Street Fighter Alpha 3 (fighting)
- Blue Stinger (action-adventure)

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Cover Image: J. P. Marshall



With two USB ports, an optical digital output, and a type III PC Card slot, PlayStation 2 is equipped for a host of current and future audio and video functions, like playing DVD movies.



Emotionally expressive characters and cinema-quality graphics make you feel like you're directing the outcome of a movie while playing *The Bouncer*, an action-adventure game.



your existing Playstation titles. The DVD capability means you also can use Playstation 2 to play DVD movies for added entertainment.

Whatever the machine, the large storage capacities of the game discs lend themselves to lots of full-motion video and pre-rendered animation sequences. And when paired with the game systems' ability to render characters with full facial mobility, even the animated characters adopt a cinematic style. Sony, Nintendo, and Sega have all shown remarkable demonstrations of animated characters smiling, frowning, and even rais-

HERE ARE A FEW TITLES you'll likely see when Playstation 2 launches in the United States next fall:
Tekken TAG Tournament (one-on-one fighting)
The Bouncer (interactive action-adventure movie)
GT2000 (car racing)
Dark Cloud (role-playing game)
Final Fantasy VIII (epic adventure)

ing one eyebrow. The hope is that such realism will lead to new genres of games and other types of software that would be designed to appeal to more mature (over age 18) audiences looking for something other than the virtual shooting spree that seem to dominate the most typical of today's video game offerings.

Adults will also want to take note of the online component of the new systems. Dreamcast has a 56.6 kilobits per second (Kbps) modem built-in for online gaming, e-mail, Web browsing, and chat. And Sony has promised a Playstation 2 modem in 2001, when the company thinks high-bandwidth Internet service will be available nationwide. Through that big data pipe, the company plans to offer online gaming and shopping, with games, music, and movie titles available for downloading to an optional hard drive. (Nintendo hasn't committed to any online plans at this point.) This development hints at the direction that the generation-after-next game machines will head toward: They won't be merely game machines but full-fledged entertainment consoles linked to the TV.

In the meantime, my husband will be developing new offensive strategies for his football playbook. ♦

All Fun 'n' Games

WHILE Sega's Dreamcast may be hogging the spotlight this holiday season as the only new video game system, there are plenty of great new games for the PC, Playstation, and Nintendo 64. Here are some picks.—S.K.K.



JET FORCE GEMINI
Nintendo 64
(\$60)
Battle the evil space tyrant Mizar and his

forces of alien insects in this futuristic action-adventure game.

OMEGA BOOST

Sony Playstation (\$45)
You're a time-traveling intergalactic warrior racing to defeat a sinister computer virus.

ULTIMA IX

PC (\$50)
The saga of saving Lord British and his people from the evil Guardian continues, this time in a world so real even the weather changes.



DONKEY KONG 64
Nintendo 64
(\$70)
Everyone's favorite monkey is back fighting

the bad guys in a lush, bigger world.

METAL FATIGUE

PC (\$50)
In this real time strategy game you control your legions of killer robots in outer space, on the planet's surface, and in subterranean caverns.

NOCTURNE

PC (\$50)
You're a secret government agent battling werewolves, vampires, and zombies in a supernatural world.

TIBERIAN SUN:

COMMAND AND CONQUER PC (\$50)
Warring clans duke it out on a battlefield that can be blasted by weapons in this real time strategy game.



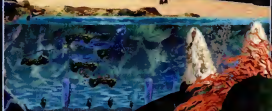
DRAKAN: ORDER OF THE FLAME
PC (\$50)
Engage in fiery duels as you search for your missing twin brother astride the back of a flying dragon.



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Unity

Zarya

Zvezda

Soyuz

Interim Control
Module

Zarya

With Russia's role in doubt,
NASA scrambles to revise plans
for the International Space Station.

Are the Russians Lost in Space?

By James Oberg

COINED BY BOB SILLERY

SAMPLING 125 YEARS OF *POPULAR SCIENCE*



Birth of an Oyster

125 PART OF POPULAR SCIENCE'S
YEARS AGO ongoing presentation of unusual creatures was the oyster. Some do not lay eggs like many mollusks, we said, but are viviparous, sending forth their young alive. "The eggs are dislodged from the ovaries and committed to the nursing care of the gill and mantle until tiny

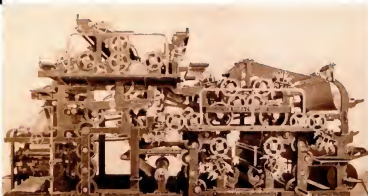
frý' are spit forth in vast numbers from the shell." Known as spat, they are scarcely larger than a pinpoint. One is shown greatly magnified at above right.—*December 1874*

New Russian Secret Weapon

25 YEARS AGO SOVIET nuclear physicists created a new element—No. 106 in the periodic table of elements—the Tass news agency reported. Scientists at the

Dubno atomic research center near Moscow created the element by bombarding lead nuclei with accelerated chromium.—*December 1974*

For more information on one of the newest elements, the 114th, see "Best of What's New" in this issue.



Turn-of-the-Century Printing

100 YEARS AGO IN THE last year of the 19th century, printing presses like this monster could spit out 36,000 16-page papers or 24,000 24-page papers per hour. It came with a color attachment for printing three colors on outside pages. "The mechanism is so perfect that any derangement, however slight, is instantly apparent to the mechanist in charge."—December 1899

Today's printing presses are producing full-color pictures, stories, and ads on both sides of each page simultaneously for products as large as 160 full-size or 320 tabloid pages at speeds that can exceed 80,000 per hour. See www.popsci.com for an extended version of "Development of the American Newspaper."



Hottest Hot Rod

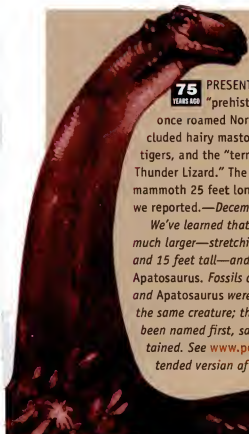
50 YEARS AGO SOME automotive experts consider the burst of record setting right after World War II as the dawn of the hot rod era, and this ultra-tapered, aluminum-bodied speedster was part of the wave. Home-assembled out of souped-up stock car and aircraft parts and only 30 inches high, the prosaically named No. 5 burned across Utah's salt flats and back at a record 189.74 mph. At the top speed, the Mercury engine turned up to 5,400 rpm and delivered better than 225 horsepower.—*December 1949*



Bye-Bye Brontosaurus

75 YEARS AGO PRESENTING a portfolio of "prehistoric monsters" who once roamed North America, we included hairy mastodons, saber-toothed tigers, and the "terrible *Brontosaurus*, or Thunder Lizard." The Thunder Lizard was a mammoth 25 feet long and 12 feet high, we reported. —December 1924

We've learned that the Brontosaurus was much larger—stretching as long as 90 feet and 15 feet tall—and its correct name is Apatosaurus. Fossils of the Brontosaurus and Apatosaurus were later proven to be of the same creature; the Apatosaurus had been named first, so that name was retained. See www.popsci.com for an extended version of this story.

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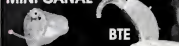
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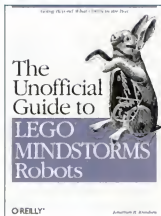
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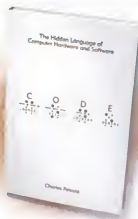
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MILESTONES



Rabinow Remembered

JACOB RABINOW, retired National Institute of Standards and Technology engineer and prolific inventor, died of cancer on September 11, 1999, at Sibley Memorial Hospital in Washington, D.C. He was 89 years old. Rabinow patented more than 200 inventions throughout his lifetime; in April 1998, he received the prestigious MIT-Lemelson award, which cited him for a lifetime of achievement in invention.

It was about that time that I first met Rabinow at his home in Bethesda, Maryland, to profile him for *POPULAR SCIENCE* ["Gadget Master," Aug. '98]. It was pouring rain as my taxi lurched onto his driveway. Umbrella in hand, Rabinow stepped out of his custom-built home to greet me. We chatted while he gave me a tour, explaining why his daughters' rooms were built to be mirror images of each other, and other such design details. From the moment we met until we parted some 5 hours later, Rabinow tirelessly entertained me with his stories of inventions—including the first magnetic computer disk, the first automated letter sorter, and a proximity fuse for guided missiles.

He was still working on a pickproof lock and a few other patents when I left him that day. When I asked what motivated him to invent, he said, "I never made much money off of my inventions, but I lived comfortably and did what I always wanted to do." Who need ask for more?—*Gunjan Sinha*

Continued from page 124
and DVDs is in the size of the pits and the width of the grooves. DVDs have much smaller pits and grooves than CDs, so more rings can fit on a DVD. That means that more data can be stored on them.

Where does NASA get the liquid oxygen and the liquid hydrogen for the fuel that powers the space shuttle into orbit?

*Marion Rappa
Harrison Township, Mich.*

IT TAKES TWO convoys of tankers to deliver the liquid hydrogen and oxygen required to get the space shuttle into orbit. Liquid oxygen comes from Praxair Inc., a plant near the Kennedy Space Center in Cape Canaveral, Florida.

Sixty highly insulated 4,400-gallon tankers empty their liquid oxygen cargo into a huge insulated sphere near the launchpad. Approximately 142,000 gallons of the minus 297.3°F liquid end up in the top section of the shuttle's external tank. Interestingly, the other 100,000 gallons or so boil away during delivery, storage, and filling.

The liquid hydrogen comes from an Air Products and Chemical Inc. plant in New Orleans. Fifty or more 10,000-gallon tankers with even more insulation make the long trek to deliver the ultra-cold liquid hydrogen to another sphere at the launchpad. Nearly 386,000 gallons go into the bottom section of the external tank. At minus 423.2°F or lower, liquid hydrogen is less than 40°F from absolute zero. ♦

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No more dangerous driving. Chances are, you've seen people driving down the road, cradling a cell phone on their shoulder, as they try to carry on a conversation while navigating traffic. With the increasing number of cell phone users on the road, the problem has gotten progressively worse. You've seen them, drifting across the center line while they're talking on the phone. For that very reason, some states have enacted legislation banning the use of cell phones in cars, unless they are operated hands-free. Now, there's a great new way to carry on conversations that's safe, convenient and affordable. The

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THE FACTS

Call of the Wild

CHILDREN'S stories such as "Little Red Riding Hood" and "The Three Little Pigs" have depicted wolves as destructive, frightening creatures roaming the wild. Movie portrayals of violent and danger-

ous werewolves have also damaged the reputation of wolves. In reality, these animals are social, nurturing creatures that often spend the better part of their day playing with and tending to their young.

—compiled by Becky Orfinger

CANIS LUPUS, THE GREY WOLF, IS the largest member of the canine family. While the distinctions between wolves are still debated in scientific circles, there are two recognized species of wolves: *canis lupus* and *canis rufus*, the red wolf.

Pack sizes vary from a pair to perhaps 15 individual wolves. It seems that the size of prey affects pack size, however—so a larger pack is not uncommon if, say, moose is regular fare on the wolves' dinner menu. Smaller prey or scarcity of food brings a corresponding decrease in pack size.

WOLVES CAN RUN AN AVERAGE speed of about 25 mph over a distance of several miles. They are capable of hitting 35- to 40-mph speeds in shorter bursts, however, such as when pursuing prey.

The grey wolf had one of the widest distributions of all mammals on the planet. It once roamed North America, Europe, and Asia, but years of persecution have reduced its numbers significantly, especially in Europe.

IN ALASKA, THE NORTHWEST TERRI- tories, and the former Soviet Union, the grey wolf has a thriving population. In the Northwest United States, however, the grey is almost extinct, with a population of perhaps 30. Farther south in the United States the grey has disappeared completely. In Mexico, researchers speculate that fewer than 10 greys survive.

The grey wolf became extinct in England about 1486; it disappeared from Scotland in 1743 and from Ireland in 1770.

ADULT WOLVES EAT AN AVERAGE of 5½ to 13 pounds of food a day.

The life span of a wolf can range from 9 to 14 years. A lone wolf in the wild is rare.

THE LARGEST WOLVES MAY TIP THE scales at close to 175 pounds, although 80 pounds is considered average. The smallest may weigh only 30 to 45 pounds.



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Why does the room seem to keep rotating after I've stopped spinning in circles?

slaggers@yahoo.com

AFTER YOU STOP your body from spinning, the perilymph, or fluid in your inner ear, keeps swirling around for a few moments, just as soup in a pot keeps swirling for a second or two after you stop stirring it. That small amount of fluid causes tiny hair-like sensory cells that line the bottom of the inner ear to bend in the direction of the swirling, much like seaweed on the ocean floor tilts in response to current. It takes a few moments for the perilymph to come to a standstill and for the sensory cells, called cilia, to return to their upright position. That lag time

is what gives you the odd perception that the room is spinning.

The normal position of the cilia at rest is upright. When the cilia are tilted in one direction, as from spinning, the mechanical energy of spinning is converted into electrical energy. These electrical impulses travel from the cells through the nervous system to the brain, where they are interpreted as circular motion.

A dancer or figure skater performing a spin keeps her eyes fixed on one point in the distance during each revolution until the last possible moment. Her head is the last part of her body to make the turn, and she immediately refocuses her eyes on the same spot as soon as her head comes around the circle. Her perilymph doesn't get enough momentum to swirl in a circle, preventing, or at least lessening, the

sensation of dizziness and the perception that the room is spinning. And that's a good thing, too. It wouldn't be very graceful for a dancer to stagger offstage after the grand finale!

How does a DVD disc hold so much more data than a CD?

J_chun@pacbell.net

IN MANY WAYS, CDs and DVDs are identical. They are the same size and store data in grooves as a series of pits. Upon playback, a laser scans each groove and is reflected in a different way, depending on whether it hits a pit or another part of the surface. These variations in light are then translated into the ones and zeros of a digital signal.

The difference between CDs

Continued on page 129

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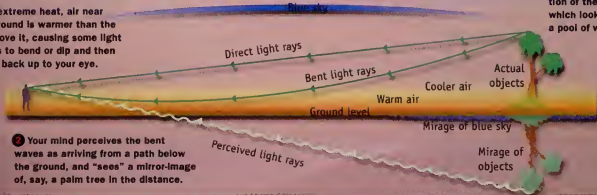
A Mirage

ACROSS BAKED TERRAIN on a blistering hot day you see a glistening pool of water. As you approach, it disappears. You've experienced one of the most famous types of mirages and one of the most dramatic of optical illusions. Add the reflection of a palm tree in the water and you'd have an imaginary oasis.—*Bob Sillery*

1 In extreme heat, air near the ground is warmer than the air above it, causing some light waves to bend or dip and then curve back up to your eye.

2 Your mind perceives the bent waves as arriving from a path below the ground, and "sees" a mirror-image of, say, a palm tree in the distance.

3 Slight variations in air temperature near the ground also cause a shimmering reflection of the sky, which looks like a pool of water.



it works, NASA will contract with a manufacturer to produce a series of CRVs. But under current schedules, the first CRV won't be docked at the station until early 2003 at the soonest. Until then, if a permanent crew stays aboard ISS, it must have a Russian-provided Soyuz on hand.

NASA may also have to come up with a replacement for Russia's unmanned Progress freighters, which were supposed to provide regular cargo service to ISS and bring up fuel to keep the station from gradually slipping out of orbit and burning up.

"Step 2" in the contingency plan NASA sent to Congress in October 1998 is to modify the rocket propellant plumbing in space shuttles so as to be able to use extra fuel to reboost the entire station while the shuttle is docked ["Shuttle Gets a Boost," Aug.]. This will cost \$90 million. Although using the shuttle for this function is very inefficient—the thrusting must raise the orbit of both the station and the 100-ton shuttle, then later lower the shuttle by an equivalent amount—it is essentially "free" because it relies on fuel reserves left over from the shuttle flight.

NASA also proposes building a new Propulsion Module, at a cost of \$350 million, not including the shuttle flights required to launch and service it. The earliest possible launch date for this module is February 2002.

Without the promised Progress missions, NASA has budgeted additional shuttle flights that will haul supplies up to the station. NASA insists that each flight will cost only \$100 million, contrary to the widely accepted value of \$500 million per launch. Additionally, NASA anticipates the outright purchase of Russian supply missions, but no cost estimate has been given. (Most outside experts put the price of a single Soyuz or Progress launching at about \$75 million.) In the long range, NASA plans to encourage the development of European and Japanese unmanned supply vehicles—at no cost to the United States but at a price tag of up to half a billion dollars for its partners.

Under the "official" NASA space station plan, the year 2000 will see 10 Russian launches to support ISS. That's twice the highest launch rate of any year in the past decade and assumes no flights to Mir. NASA has contingency plans for what it calls a "minimum Russian support scenario," which consists of three Progress and two Soyuz launches per year (that is, their entire current production capacity). That would reduce station power by 5 kilowatts and reduce propellant supplies by about 2 tons per year, requiring an additional two shuttle flights per year to compensate.

POPULAR SCIENCE has obtained the presentation charts from an October 1998 NASA briefing on ISS contingency plans, given by Mission Integration Manager Keith Riley. They graphically illustrate the quandary that NASA has put itself in, because even the page titled No Russian Program Support assumes that there *will* be continuing Russian participation.

In this worst-case scenario, the Russians drop out completely in 1999. However, NASA must still depend on Russia's Mission Control Center in Moscow to operate the



Zarya section of the station. Somehow NASA expects to find a way to persuade the Russians to keep up their control activities until the ICM can be launched.

What if they don't? That merely means the loss of Unity, the one U.S. module attached to Zarya. NASA already had developed contingency plans for the loss of the module during launch, and they could be quickly implemented. There is a spare unit, a "structural test article," which could be made flight-ready in about a year. Station assembly could be resumed by mid-2000.

According to Riley's presentation last October, the other two critical replacement items are the Propulsion Module and the Crew Return Vehicle. Since there would be no way for any long-term crew to evacuate the station prior to the delivery of the CRV in 2003 or later, astronauts would never stay onboard, and so there wouldn't be any need to deliver a U.S.-built life support module until about that same time.

In the end, NASA has painted itself into a corner. The agency can handle more delays, and it can handle the loss of Russian logistic support flights. But without the delivery of Zvezda and without the open-ended availability of semiannual Soyuz launches to keep a bail-out capsule attached to the station, NASA is faced with a three-year delay in leaving a permanent crew aboard the station. Making matters worse, NASA is reported to be behind schedule in readying its U.S. Laboratory module for a scheduled April 2000 launch, and a planned shuttle mission to service the station has been postponed to mid-February because of wiring damage discovered on a shuttle flight last July.

The potential impacts of a prolonged delay in assembling the space station are staggering. They range from lost research opportunities to lost international support, and perhaps even program cancellation. So NASA has realized it must pay any price to keep the Russians onboard through the launch of Zvezda and then for several years of Soyuz launches. And the Russians know it too. The only issue remaining to be decided is how much American money will be transferred to the Russian Aviation and Space Agency, and what the official invoices will say. ♦

SOMEWHERE, GEORGE HAD MADE A MISTAKE. His Catalan opening had been flawless. Yet, somehow, his opponent had forced his retreat and now held him in check. With his only remaining rook lured out of position and pinned, the situation appeared hopeless. This isn't Chessmaster, he thought, there is no replay option in this game. His mind raced back to the magnificent chess sets of Chessmaster. The lessons learned. The gambits and endgame strategies. The Chessmaster opponents against whom he had matched wits and sharpened his game, as he progressed through tutorials in various levels. The voice of the Chessmaster, coaching him. And suddenly, in his hour of need, he heard the voice again: "Counterattack in the center... N-Q4." Why hadn't he seen it before?



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its own life support system until 2002. NASA has looked at extending the shuttle's capability to stay docked to the station from the current eight days up to 30 days, but the results were not encouraging.

Even if NASA could speed up the development of a life support module for the crew, how would they get home in the event of an emergency? Currently, the only manned vehicle capable of long-term missions to the station is Russia's three-man Soyuz capsule. NASA originally planned to have one Soyuz launched to the station every six months, to support a three-man permanent crew, as an emergency rescue vehicle. Later, the Soyuz lifetime would be extended to 12 months, so two Soyuzes would always be available,

and the station crew could be expanded to six people. The concern now is that Russia may not be able to deliver the Soyuz vehicles it promised.

Since the Soyuz is cramped (among American astronauts, about half can't even fit into its seats) and makes a rough landing (not good for medical emergencies), NASA has long been interested in developing a larger, gentler Crew Return Vehicle, or CRV. A special team at NASA's Johnson Space Center is now designing, testing, and building a CRV prototype called X-38, NASA's first new manned space vehicle in a quarter century.

NASA plans to deploy an unmanned X-38 from a shuttle in late 2000, to demonstrate a re-entry and landing. If

The End Is Near for Mir

ONE REASON Russia has had trouble funding the construction of the International Space Station is because the Russians have been reluctant to part with their 13-year-old Mir space station. Maintenance and supply missions to keep Mir flying have occupied spacecraft, crews, and other resources that could instead be devoted to ISS.

Deorbiting Mir is risky. It's big, it's shaped all wrong, and nothing like it has ever been brought down from space. Mir is 130,000 pounds of laboratory and habitat modules, giant solar panels, and docking adapters. Its labs contain 12 tons of scientific equipment, including a heavy and well-insulated high-temperature furnace.

There are only two ways to get the space station out of orbit. The safest method is to deorbit Mir one piece at a time. Cosmonauts would undock each section and attach a retrorocket pack to it. After the piece was moved a safe distance away from Mir and the cosmonauts were back inside the station, commands from the ground would fire the

rocket and bring the piece down into the Pacific Ocean. Disassembling the whole station by this method could take six months and multiple cosmonaut missions.

But the Russians don't have that kind of money, so they plan to deorbit the entire station at once. The "final" crew left Mir on August 27, with the station about 220 miles up, but one more crew may go up in February or March to do some last-minute preparations for deorbit.

In either case, an unmanned Progress ship laden with fuel will dock at Mir's leading edge sometime next year, and any cosmonauts aboard the station will depart in their Soyuz spacecraft. Some time later, the Progress retrorockets will fire, slowing Mir enough to bring it down through the atmosphere and into the Pacific.

Will all of Mir burn during its fiery re-entry? Not likely. Mir will wobble and tumble. Pieces of the station will break off, some incinerating and others splashing down in the ocean. The process is completely unpredictable.

Even now, Mir's fate is not yet sealed. The Russian company Energia RSC is still trying to scrape together private funding to keep the station aloft.

"Everything could change," says one NASA official. "When it comes to Mir, we never know."—*Jim Scheffer*

① The station's orbit gradually decays over a period of several months to a year (it slowly loses speed and begins dropping in altitude).

② A Progress unmanned ship docks with Mir.

③ Progress fires its retrorockets to dramatically reduce the speed of the orbiting station.

④ Unable to resist Earth's gravitational pull, the slowed Mir falls out of orbit and into the Pacific Ocean.



President Clinton orders NASA to review the International Space Station, which then goes through further redesigns. NASA invites Russia to join the program.

1993

Congress gives NASA \$250 million to begin preparing backups for Russian elements that have been excessively delayed. As part of the contingency plan, NASA decides to buy an unused Navy spacecraft and turn it into an Interim Control Module.

1997

inside of the ICM's propellant tanks, to feed liquid into fuel lines. "That was a challenge," Jacobi recalls, because the tanks are 52 inches in diameter and were built with only 5-inch-diameter inspection ports. The ducting had to be built in sections small enough to fit through the holes. "It was like building a ship in a bottle," Jacobi says.

The ICM, which will not be ready for flight until late next year, is only the first of several expensive alternatives that NASA has had to develop to accommodate delays and cancellations of promised Russian contributions. According to NASA, the Russians provide the station with critical services in eight specific functions: guidance, altitude control, life support, communications, power, spacewalk support, emergency crew return, and ground support.

As a power provider, for example, the Russians originally promised to supply a module called the Science Power Platform (SPP), which would have large solar panels and gyroscopes for turning the station in different directions. The SPP would be launched piecemeal aboard three Russian Zenit boosters and would automatically dock to the station.

The Russians soon realized that the SPP would be too heavy for their own rockets. As part of an evenhanded deal in which the Russians promised to develop a new robotic supply vehicle, NASA agreed to carry the SPP into space aboard two shuttle flights. Cost to U.S. taxpayers: \$1 billion. The Russians later told NASA they wouldn't be able to build the supply vehicle, but they kept the two shuttle flights—in fact, NASA added two more flights to carry additional space hardware the Russians discovered they couldn't afford to launch on their own.

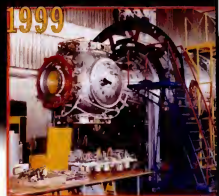
The SPP deal continued to sour. It turned out the Russians couldn't afford to build the SPP at all, even though NASA's station design depended on the promised electrical power, heat-dumping radiators, and steering gyroscopes. So now NASA is considering an additional U.S.-built photovoltaic power module and may have to fly the entire space station pointed in a different direction to maximize solar power production.

When the United States and Russia first agreed to build a station together, the downside of cooperation seemed slight: Placing the station in a more northerly orbit (so the Russians could reach it) meant that NASA



In October, NASA submits a contingency plan to Congress. A month later, Zarya (top), the station's first element, is launched. In December, the Unity module (bottom) is added.

The station assembly schedule has already undergone at least four major revisions. Congress' General Accounting Office demands that NASA finalize its contingency plan before the upcoming launch of Zvezda (below), the station's key element.



would have to accept a 25 percent payload performance penalty on each half-billion-dollar space shuttle flight to the station.

But unforeseen problems soon surfaced. Within a year of agreeing to collaborate on the station, the Russians began delaying some items and backing out entirely from others. Year by year, the list of promises has shrunk and the costs have expanded. By last year, all the news from Russia was glum. Promised funding had totally dried up.

In October 1998, NASA reported to Congress how it planned to handle the threatened loss of key Russian elements. NASA's "Step 1," costing \$250 million, had already been approved in mid-1997. That was when NASA at last realized that Russia's ambitious schedule for Zvezda was hopelessly optimistic. NASA insisted that the station's first module, Zarya, be modified so that it could be refueled from docked supply ships.

For the engineers actually building the project—the most ambitious international construction effort in history—the schedule and budget setbacks are all water under the bridge. The engineers are faced with a practical and more pressing problem: What can be done *now* to proceed with the project in the least expensive way?

The question is no longer theoretical, since the first two pieces of the International Space Station are already in orbit. The Russian-built but U.S.-funded Zarya (Russian for "dawn") and the U.S.-built Unity were hooked together on a shuttle mission last December, then left to orbit unoccupied. Their future existence depends on the timely launchings of support missions.

The clock is ticking. Zarya's computers are rated for only an 18-month lifetime, which means that a new vehicle must be docked to it by May 2000 to take over the station's control. If it's not going to be Zvezda, then the ICM must be sent up in its place. But since NASA needs a full year to prepare for a shuttle mission, the decision to send up the ICM should have been made seven months ago.

Even if the ICM could be launched quickly, it is only a short-term and partial stand-in for Zvezda. The ICM does not provide life support—air and water—for a long-duration crew. Under current plans, NASA won't be launching

The Long Road to Space

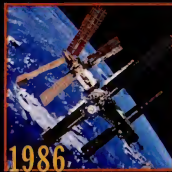
THE INTERNATIONAL Space Station has gone through a number of names and design changes in its long march toward orbit. Here's a look at its troubled history.

1984

In his State of the Union address, President Ronald Reagan announces plans to build and launch a space station within 10 years.

1985

The United States signs an agreement with Canada, Japan, and the European Space Agency to cooperate on development of the space station.



1986

The first element of Russia's Mir station (above) is launched. The United States later pays \$400 million to dock shuttles with Mir.

1990

Congress cuts the budget for the international station, which is now called Freedom, and NASA revises the schedule to delay launch of the station.



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but has been repeatedly delayed, pushing back the entire assembly sequence. And even if this first major Russian-funded component of the station does go up as planned, other promised Russian contributions may never be delivered, due to lack of funds.

When Russia was brought aboard the International Space Station project in 1993, NASA promised the partnership would save billions of dollars and several years of construction. More important, the station offered a diplomatic opening to the post-Soviet Russian government, without which President Clinton may have cancelled the entire project, already hopelessly over budget.

Although NASA's rosy forecasts were way off target—the Russian presence has contributed to vast cost overruns and schedule slips—things could get even worse. If the Russians drop out of the program now, or are expelled, replacing them will take at least three years and much, much more

money—threatening the project with cancellation again.

But unbeknownst to most people, NASA has drafted a backup plan for building a station without Russian help. Over the past few years, the agency has quietly developed several spacecraft of its own that can serve as understudies for promised Russian elements. And before Zvezda is launched, Congress expects NASA to finalize its contingency plan for completing the station without Russia.

That won't be easy. The Russians are in what's known in space jargon as "the critical path." The other 15 nations participating in the project are relying on Russia not only for crew life support, but also for such key components as the crew's emergency escape system, rockets that keep the station in the proper orbit, and some of the solar panels that provide power. With the Russian equipment, the station's capability is impressive. Without it, the project is in deep trouble.

Just consider the dilemma of the Interim Control Module, or ICM, a 10-ton conglomeration of computers,

rocket engines, and propellant tanks. Faced with the possibility of excessive delay of some Russian components, in 1997 NASA finally decided to purchase this spacecraft, a modification to a design already used in a military program managed by the Naval Research Laboratory (NRL).

But if you look at NASA's official "Assembly Sequence" for the station, you won't see the ICM anywhere. That's because NASA still doesn't know which potentially missing Russian spacecraft the ICM will be used as a substitute for. And depending on where and when it is to be used, engineers have to install different latching equipment and computer software.

If it stands in for a delayed or cancelled Zvezda, the ICM would hook to the Zarya module already in orbit. But if Zvezda is delivered and the Russians subsequently renege on several promised refueling flights, then the ICM would be loaded with fuel and attached to another module, using a different type of docking mechanism.

The ICM is cheap by space standards, because it is being assembled mainly from "residuals," hardware that had been in storage. "We already had a structure, the rocket engines, the tanks, and a lot of electronics," NRL program director Al Jacobi explains. These components had originally been designed for a top-secret Pentagon payload that would have ridden into space aboard the shuttle Challenger in the late 1980s. But after Challenger exploded, most military payloads were diverted to expendable boosters, and the vehicle hardware was stashed away.

Still, the module required "sizable modifications," according to Jacobi. To begin with, the original vehicle was a "spinner": It slowly rotated around its long axis as it drifted through space. For the space station, the module had to be stabilized.

Slow spinning is desirable for space flight, Jacobi says. It evens out the vehicle's temperature and causes the propellant in the tanks to settle into a predictable location. Without spin, significant design changes were needed. Engineers had to add a new thermal control system, including a heat pipe and thermal radiators to dump excess heat generated by sunlight and onboard electronics—doubly important, since NASA required the redesigned module to carry twice as many computers as the original.

NRL engineers also had to add special ducting to the

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CONTINGENCY PLAN

NASA's Plan B

If Russia's Zvezda module is launched soon, the International Space Station will begin taking shape as planned (left). But if Zvezda and other Russian contributions fail to materialize on time, the station could be headed for a very different look (right).

SOMETIME IN THE next few months, the third and arguably most critical element of the International Space Station is scheduled to be launched aboard a Russian Proton rocket from the Baikonur cosmodrome in Kazakhstan. Designed and built in Russia and modeled after the core module of the Mir space sta-

tion, Zvezda ("star" in Russian) will serve as the crew living quarters while the station is being assembled.

But will Zvezda, which until recently was known as the Russian Service Module, actually be in orbit soon after you read this? The module was originally scheduled to be launched in early 1998

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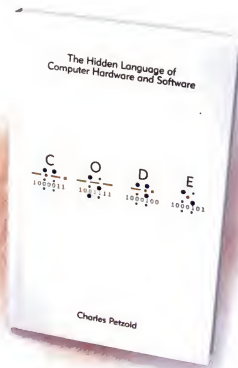
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